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**An Examination of Technology Transfer and Technological  
Learning through Intermediaries: The Case of Intermediaries  
In the Omani Oil and Gas Sector**

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**Submitted in partial fulfilment of the regulations for the degree of  
Doctor of Philosophy**

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## **Declaration**

I hereby declare that this thesis has not been submitted, either in the same or different form to this or any other University for a degree.

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November 2015

## **Abstract**

There is large body of research that has investigated inter-firm technology transfer and technological learning through the direct producer-user relationships within the context of developing countries. However, due to the growth in the technology transfer market, there has also been an increasing tendency for users to become isolated from producers of technologies, as new actors have emerged, which have been named technology intermediaries. The motivation for this thesis is driven by the absence of both theoretical and empirical studies examining technology transfer and learning through intermediaries, particularly in emerging nation contexts, what factors influence the functions of intermediaries along the process, and how those factors influence the recipients' learning. By learning from the technology transfer experiences of the two main users of technologies in the Omani oil and gas sector, namely Petroleum Development Oman (PDO), and Oman Liquefied Natural Gas (OLNG), this research tries to address this theoretical and empirical gap.

Through semi-structured interviews, this study explored technological learning during the technology transfer through intermediaries from the perspective of 48 employees (Omani and expatriates) at different levels of hierarchy (managers, section heads/team leaders, site engineers) and from different departments across the two firms. The perspectives of those employees are supplemented by data such as annual reports, which also serves as important triangulation instruments to validate the data collected from respondents. Within-cases and cross-cases qualitative and interpretive content analysis was employed to analyse the empirical data gathered from the two firms.

The empirical evidence identified five main factors that influence the functions of intermediaries along the transfer process. These are the proximity of intermediaries with users (geographical and cognitive), specialization of intermediaries (industrial or technological), characteristics of technologies (tacitness, complexity, newness/ novelty), recipient firm's absorptive capacity, and recipients firm's technology strategy. A good understanding of these factors can

increase the ability of firms to reap the maximum potential of inward technology transfer for local learning through intermediaries.

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# **1 INTRODUCTION**

## ***1.1 INTRODUCTION***

This thesis presents and discusses the results of a multiple-case study that investigated inter-firm technology transfer and technological learning through technology intermediaries from a user perspective within the context of the developing countries. Specifically, this study aims to identify the different functions that different intermediaries perform along the transfer process, examine the factors that influence those functions, and investigate how those factors might influence firm's learning.

The findings of this study are based on the technology transfer experiences of the two main and largely state-owned firms of the Omani oil and gas sector, namely Petroleum Development Oman (PDO) and Oman Liquefied Natural Gas (OLNG).

While these two firms are engaged in a process of technological learning through technology transfer, they have weak internal R&D capability, are geographically isolated from most technological sources, and frequently access external technologies through intermediaries. This study is driven by the need to understand how intermediaries influence the transfer of technology and technological learning for major firms in an emerging country.

The nine main sections of this chapter present an overview and short summary of the thesis and the research that has been conducted.

## ***1.2 MAIN CONCEPTS***

This study examines the different functions of technology intermediaries along the technology transfer process and the factors that influence those functions in supporting firm's learning. Technological learning theory through technology transfer assumes firms that lack internal knowledge production capacity can learn from external sources through a process of technology transfer (Kim, 1980; Kumar et al., 1999; Lall, 1992; Viotti, 2002). According to Kim (1980) and Dahlman et al. (1987), technological learning through technology transfer goes through three

consecutive stages; acquisition, assimilation and improvement. Implicitly, this theory assumes technologies are acquired from their sources and, consequently, as Grant (1996) and Cyhn (2002) argued, technological learning occurs mainly through the direct source-recipient interactions.

However, other studies highlighted that effective technology transfers for learning involve two main stages prior to these three stages, and in particular prior to the actual acquisition of external technologies. These stages are demand articulation for external technologies (Bessant and Rush, 1995; Boon *et al.*, 2011; Szulanski, 1996) plus scanning the market for available options in order to identify a range of options and select the most appropriate (Bessant and Rush, 1995; Howells, 2006).

Despite the fact that the technological learning theory based on technology transfer focuses primarily on firms that lack initial technological capability, the theory does not address adequately how such firms recognize their internal demands for external technologies, or how they learn about the external technologies prior to acquiring them, and how to assess the various options in order to select the appropriate options. To fill this gap, the initial model of technological learning theory (Kim, 1980; Dahlman et al, 1987) is modified in this study to include these two stages – demand articulation and market scanning.

In addition, new actors, widely termed as technology intermediaries, have emerged as one of the main actors involved in the technology transfer process and often assume dominant roles (Howells, 2006). While technological learning theory emphasizes the direct producer-user interactions for learning, the theory does not adequately address how the emergence of intermediaries between producers and users might influence the transfer and learning process. Moreover, previous studies on technology intermediaries identified that different types of intermediaries perform different functions along the transfer process but failed to provide an adequate explanation of the factors that influence the different functions, or what makes different intermediaries perform certain functions.

In order to address these concerns, this study adopts the following concepts:

- *Technology transfer*: the process that transfers the physical object and associated technological knowledge of the technologies being transferred (Grant, 1996; Kumar *et al.*, 1999).
- *Technological learning*: the process of developing technological capability (Kim, 2001; Lall, 1992) over the five stages of technology transfer, including demand articulation, market scanning, acquisition, assimilation and improvement/innovation (Bessant and Rush, 1995; Kim, 1980; Szulanski, 1996).
- *Technology intermediaries*: organizations or individuals engaged in any of the five stages of the technology transfer processes between suppliers and end-users, and possibly providing a variety of intermediation functions to support users along the stages of technology transfer (Bessant and Rush, 1995; Clarke and Ramirez, 2013; Howells, 2006).

### **1.3 RESEARCH PROBLEM**

Technological learning theory recognizes that firms with modest internal technology production capacity (i.e. R&D) can learn and upgrade technologically by transferring and absorbing technologies from external sources (Bell and Pavitt, 1993; Kim, 2001; Viotti, 2002), through the direct producer-users relationship (Cyhn, 2002). This direct relationship allows for immediate producer-user interactions and feedback that are thought to enhance user's absorption of tacit and complex technologies (Cyhn, 2002; Grant, 1996; Lall, 1992).

However, technological learning over the technology transfer process is not an automatic result of the direct producer-users interactions. It is a complex and resource consuming process (Bell and Pavitt, 1993). It requires competent suppliers capable of simplifying and communicating external knowledge to a level understood by different recipients (Minbaeva, 2007; Mu *et al.*, 2010), especially for recipients with weak initial capability. It also requires capable recipients to absorb and internalize external technologies (Cohen and Levinthal, 1990; Kim, 2001).

It was found that, the main capability of suppliers that directly influence the transfer and learning process is the "disseminative/transfer capacity" (Minbaeva,



2007; Szulanski, 1996); while the main capability of recipients is the “absorptive capacity” (Cohen and Levinthal, 1990; Kim, 1999). Therefore, identifying a competent supplier who is knowledgeable about technologies being transferred and capable of carrying out effective transfer is essential for learning along the technology transfer (Capannelli, 2001; Cyhn, 2002).

Most firms in developing countries are noted to possess weak initial absorptive capacity to identify external technologies, recognize their values and internalize them into their system (Figueiredo, 2001). They mostly develop such capacity as they engage in the technology transfer from advanced firms (*ibid*), mainly by interacting or working with source of technologies (Cyhn, 2002; Lall, 1992). This weak absorptive capacity is also worsened by the fact that those firms are often geographically isolated from the most original sources (producers) of technologies (Hobday, 1995; Lall, 1990) that are commonly located in developed countries. Moreover, due to the weak initial absorptive capacity, firms in developing countries also lack the cognitive proximity with suppliers who are at an advanced technological level – innovators. While technology transfer within the same firms (intra-firm) is acknowledged to be difficult and complex, technology transfer across different firms (inter-firm) is expected to be more difficult and complex (Pérez-Nordtvedt *et al.*, 2008; Szulanski, 1996). This complexity in technology transfer and learning is expected to multiply when recipient firms do not possess sufficient internal absorptive capacity to learn from external sources, or the suppliers are not the original producers or do not possess adequate technology transfer capacity.

Moreover, as most firms in developing countries lack an initial technological capability or absorptive capacity, it is still insufficiently understood how such firms identify their internal demands for external technologies prior to transferring them or learn about them. In addition, as there are various kinds of technologies with different sources, it is also not well understood how such firms know about the different options from different sources, and how they assess the different options to select the most suitable.

Nonetheless, previous studies on technology transfer and technological learning assume technologies are acquired from their original producers who, in turn, are assumed knowledgeable about the technologies being transferred. Accordingly, learning is perceived to occur through the direct producer-user interactions (Cyhn, 2002). However, several factors have emerged along the transfer process in developing countries and made the direct interactions difficult if not impossible. For instance, the growth in the technology transfer market (Tietze and Herstatt, 2010), in addition to the geographical and cognitive proximity between the sources and recipients of technologies (Boschma, 2005) have made the direct interactions difficult. Moreover, there is a growing trend with both producers and recipients in outsourcing some activities of technology transfer (Howells, 2006). Furthermore, some recipients lack skills or capability to manage effective transfer process (Bessant and Rush, 1995; Li-Ying, 2012), or to support local learning in an absence of leading producers to drive learning. Consequently, to ease some of those challenges, technology intermediaries have emerged along the transfer process. From a technological learning perspective, the immediate effect of the emergence of intermediaries on technology transfer and learning from producers to recipients has been argued by some to hinder the direct producer-user interactions (Leonard-Barton, 1984; Rosenberg, 1976). Whether the lack of direct interactions negatively influences the transfer and learning remains imperfectly understood.

Without explicitly referring to intermediaries, key previous studies on technology transfer and learning have raised concerns about the influence of the lack of direct interactions with original producers on technological learning, especially for users in developing (poor) countries that possess weak initial technological capability. For instance, Rosenberg (1976, p. 166) noted:

*"...Some of my concerns about the prospects for poor countries, which rely on the importation of foreign capital equipment are obvious...But if new techniques are regularly transferred from industrial countries, how will the learning process in the design and the production of capital goods take place? ...In the past, as I have argued, the appropriate skills were acquired through an intimate association between the user and the producer of capital goods.*

*...In the absence of these experiences, what substitute mechanisms or institutions can be established to provide the necessary skills?" (p. 166)*

This concern raises the question of whether technology intermediaries are capable of substituting the direct interactions with original producers for firms in most developing countries with weak capability. While intermediaries have been intensively found to substitute direct suppliers in terms of transferring the physical object of technologies, their roles and capability in transferring technological knowledge and driving user's learning remains not adequately understood (Knockaert and Spithoven, 2009).

This lack of understanding about the influences of intermediaries on user's learning is enhanced by the contradictory results achieved in previous studies on the influences of intermediaries on transfer and learning. For instance, Leonard-Barton (1984) found diffusion intermediaries negatively influence innovation diffusion and user's learning in the case of the Canadian health sector. Intermediaries were found not to diffuse sufficient technological information from producers to users or diffuse inadequate feedback about the innovation from users to producers, which both negatively influenced recipients' learning and technology future's development.

Similarly, through a country's survey, Seaton and Cordey-Hayes (1993) found not all intermediaries in the UK are involved in post-technology transfer support or in transferring technical information. The study found intermediaries are mostly involved in the transfer of physical technologies. Likewise, In the case of the UK biotechnology innovation sector, Shohet and Prevezer (1996) found technology transfer agents -as intermediaries operating along the university-industry technology transfer framework- are not involved in the actual transfer of knowledge between sources and recipients. The study found agents mostly engaged in the transfer of physical technologies.

On the other hand, other studies found intermediaries positively enhance technology transfer and innovation diffusion from sources to recipients. For instance, in the case of the UK enterprise initiative, Bessant and Rush (1995) found consultants -as intermediaries- greatly support the transfer and learning process

through providing different advices and training to different users. Likewise, Howells (2006) found intermediaries facilitate the innovation process along the UK linear innovation system. Equally, in the case of an emerging resource based cluster, Clarke and Ramirez (2013) found intermediary organizations play a significant role in supporting technology transfer and learning among small local producers.

These contradictory results clearly highlight the lack of adequate understanding of the influences of intermediaries on technology transfer and learning processes. It is not sufficiently explained by previous studies what factors lead to positive or negative influences of intermediaries.

In addition, intensive conceptual and empirical research has examined technological learning through the technology transfer process within the direct producer-user relationship and has identified several factors influencing the process (Easterby-Smith *et al.*, 2008; Kim, 2001; Kumar *et al.*, 1999; Szulanski, 1996; Viotti, 2002). However, when suppliers are intermediaries, the factors that influence the transfer and learning process have not received adequate attention thus deserve further investigation. In addition, the roles of intermediaries as one of the principal actors along the transfer process are not well established or understood compared to other actors such as producers or users (Knockaert and Spithoven, 2009). Therefore, understanding the functions of intermediaries along the transfer process, the factors that influence those functions, and how that influences the recipient's learning, are critical to gain a thorough understanding of technological learning in firms that access external technologies through intermediaries.

## **1.4 INTRODUCTORY BACKGROUND**

In general, firms learn and develop various capabilities in order to remain competitive: one of these capabilities is technological capability (Bell and Pavitt, 1993; Viotti, 2002). From a knowledge based view, technological capability has been understood as the "effective use of technological knowledge in production, engineering, and innovation" (Kim, 2001, p. 298). It is argued that firms develop these capabilities through a process of technological learning that is implemented

differently by firms in developed and developing countries (Malerba, 1992; Kim, 1999). While learning through science, technology and innovation (or R&D-based learning) is adopted by most firms in developed countries that have already established a certain level of technological capability (Malerba, 1992), most firms in developing countries often learn by transferring, absorbing and internalising technologies mostly produced by firms in developed countries (Bell and Pavitt, 1993).

Technological learning in developed countries is directed mostly toward producing new innovation while learning with most firms in developing countries is aimed initially at adapting external technologies for local applications (Viotti, 2002). International technology transfer is the channel for firms in developing countries to access and learn from external sources of technologies (Kumar *et al.*, 1999; Lin, 2003; Viotti, 2002), and to interact with technology producers (Cyhn, 2002).

However, technological learning does not occur as a by-product or an automatic result of the transfer process as learning requires different resources and efforts (Bell and Pavitt, 1993; Ngoc Ca, 1999). Instead, it is an interactive process between different elements including the capability of source and recipient of technologies to transfer and absorb (Easterby-Smith *et al.*, 2008; Mu *et al.*, 2010), the characteristics of technologies being transferred (Lall, 1992; Simonin, 1999; Szulanski, 1996), and the proximity between source and recipients (Arundel and Geuna, 2001; Boschma, 2005). Because of the influences of these and other elements, not all technology transfer processes lead to technological learning on the recipients side (Kumar *et al.*, 1999; Pérez-Nordtvedt *et al.*, 2008).

Earlier studies on technological learning for firms in developing countries focus their analysis mainly on the internal efforts of firms to learn from external technologies – absorptive capacity (e.g. Bell and Pavitt, 1993; Kim, 2001, 1999; Figueiredo, 2001; Viotti, 2002). While these studies focussed on the absorptive capacity, they shifted the understanding and analysis of absorptive capacity from R&D-based (Cohen and Levinthal, 1990; Mowery and Oxley, 1995), to the different intensity of efforts executed by firms to internalize external technologies. These

efforts include the development of the capability of individuals within the firm through education and training (Figueiredo, 2003; Viotti, 2002), the activities of reverse engineering (Cyhn, 2002; Kim, 1999), and the interactions with direct suppliers (Capannelli, 2001; Cyhn, 2002).

Another stream of studies established that a technology constitutes two sides; physical objects and technological knowledge (Kumar *et al.*, 1999; Lall, 1992). Accordingly, an effective technology transfer for learning should include both elements of technologies. This stream argues that technological knowledge is the essence of learning and is largely tacit in nature (Lall, 1992), which is found sticky and attached to its sources (Grant, 1996; Steensma, 1996). Consequently, it is thought that effective transfer and absorption of tacit technologies requires direct source-recipient interactions (Grant, 1996; Nightingale, 1998). Besides the direct interactions, this stream of studies stresses that the transfer of the physical object of technologies without technological knowledge does not lead to effective technological learning. In general, this stream shifted the conventional understanding of technology transfer to knowledge transfer process.

As technological learning in developing countries is mainly based on technology transfer from external sources, a more recent studies on technology transfer and technological learning highlighted that learning is an interactive process between the source and recipient of technologies (Cyhn, 2002; Easterby-Smith *et al.*, 2008). This stream emphasizes that understanding technological learning requires understanding the roles and capability of sources and recipients of technologies along the transfer process, to ensure their interactions are fruitful. Moreover, these studies found that the ability of the source to articulate and communicate technologies (through demonstration and adaptation) to a level understood by the recipients directly influences the transfer and user's learning (Minbaeva, 2007; Park *et al.*, 2013).

However, technological learning theory during technology transfer implicitly assumes that learning goes through a sequence of three stages that starts with the acquisition of external technology. For instance, Lall (1990) argues that learning with most firms in developing countries always needs the acquisition of external

technologies. While this need is recognised, it remains not sufficiently explained how firms in developing countries that initially lack adequate technological capability implement the acquisition process. For instance, it is not explained how such firms define their internal needs for external technologies or how they learn about the external technologies so they can acquire them. Similarly, it is not amply discussed how these firms assess the various technologies from different sources in order to select the most appropriate that suits internal demands.

Consequently, this study argues that although technological learning certainly requires the import of external technologies, the import process is preceded by the demand articulation stage of technology transfer. After the internal demands are recognized, the second stage is to scan technology market in order to identify and to select the option that meets the internal demands. Accordingly, this study argues that the demand articulation and market scanning stages are crucial for effective technology transfer and learning.

Despite the significance of these two stages for effective technology transfer and learning (Boon *et al.*, 2011; Szulanski, 1996), technological learning theory within the context of developing countries remains silent about these two stages and rarely addresses them. Whether the suppliers (intermediaries) or recipients perform them remains inadequately understood within the existing theory. These two stages have been ignored without specifying who performs them or what they involve.

Moreover, technological learning theory implicitly assumes that technologies are acquired from their producers, and consequently, there is a direct producer-user interactive learning (Capannelli, 2001; Cyhn, 2002). However, as technology intermediaries have emerged between suppliers and recipients along the technology transfer process, the theory does not accurately address how the emergence of intermediaries might influence the overall transfer and learning process. Some scholars suggest that the direct effect of the intermediaries along the transfer process is that they hinder the source-recipient direct interactions and, consequently, technologies might not effectively transfer to recipients

(Leonard-Barton, 1984; Leonard-Barton and Sinha, 1993). This effect undermines the assumptions about direct interactions in technological learning theory.

While intermediaries are recognised of being capable for transferring the physical part of technologies from suppliers to users, their ability to transfer technological knowledge requires further investigation. Moreover, as interaction with producers is argued to enhance user's learning (Cyhn, 2002), what happens in the absence of such interactions, for example whether intermediaries substitute other means, remains not sufficiently understood. The existing technological learning theory does not adequately addresses how the emergence of intermediaries influences the firm's learning. We suggest the new division of labour introduced by the emergence of intermediaries might have great effects on technology transfer, and raises important questions for firms in developing countries, as they are often highly dependent on learning how to use and adapt technology purchased from external sources.

The literature on technology intermediaries shed some light on the functions of intermediaries along the transfer process. It identifies different types of intermediaries, such as innovation intermediaries (Howells, 2006), diffusion intermediaries (Leonard-Barton, 1984), consultants (Bessant and Rush, 1995) technology brokers (Kilelu *et al.*, 2011; Ramirez and Dickenson, 2010), and technology agents (Li-Ying, 2012; Shohet and Prevezer, 1996). This literature identified different functions for intermediaries along the different stages of the technology transfer process. For example, demand articulation and need assessment (Howells, 2006), market scanning or business intelligence (Howells, 2006; Li-Ying, 2012), negotiation and deal making (Shohet and Prevezer, 1996), accessing and diffusing innovation (Clarke and Ramirez, 2011; Leonard-Barton, 1984), as well as training and long-term learning (Bessant and Rush, 1995).

Nonetheless, these functions of different intermediaries were identified without explicitly specifying the theoretical stance upon which intermediaries are examined. Furthermore, despite the ample research on technology intermediaries along the innovation and technology transfer process (see Howells, 2006), there are several points that require further investigation with respect to the end-user's



learning. First, as highlighted above, previous studies have produced contradictory accounts of influences of intermediaries on transfer and learning. Second, previous studies mainly focus on identifying and listing the different functions performed by different intermediaries (Li-Ying, 2012), without examining in detail what factors influence these functions, and how they, in turn, influence user's learning. For example, it is not clear why consultants might support users' demand articulation (Bessant and Rush, 1995), while technology agents are less supportive (Shohet and Prevezer, 1996). Similarly, it is not clear how the characteristics of technologies, such as their tacitness, technical complexity or novelty might influence the functions that the intermediaries play during the transfer process and how this might influence user's learning. Similarly, more research is needed on how the capability of intermediaries might influence the ability of end users to transfer and absorb technologies and ultimately learn.

Third, previous studies on technology intermediaries are mostly based on the experiences of intermediaries operating in a single transfer system (Li-Ying, 2012), where producers, users and intermediaries are actors within the same system. The functions and influences of intermediaries across different transfer systems that are geographically isolated or differ in knowledge base or capability have not been effectively investigated. While the geographical and cognitive proximity –for instance- have been identified to influence the transfer and learning within the direct producer-user relationships (Arundel and Geuna, 2001; Boschma, 2005; Rebolledo and Nollet, 2011), they are still not well understood, particularly how they influence the transfer and learning from intermediaries and users. In addition, there is a scarcity of research that examines the influences of prior experience and knowledge of intermediaries on their functions along the transfer process, and how that influences end-user's learning and capability development.

In general, technology intermediaries have not been sufficiently subjected to scientific inquiry from a technological learning perspective (Knockaert and Spithoven, 2009). There is a dearth of research that examines the influences of intermediaries on firm's learning and capability development along the technology transfer process, especially for firms in developing countries (Intarakumnerd and Chaoroenporn, 2013). While intermediaries have been recognized to perform a

key linkage function between producers and users of technologies in developed countries, their roles as direct suppliers are expected to be far greater and include learning elements for users that lack initial capability and are isolated from sources of technologies.

This study was initiated as an attempt to respond to these gaps in the knowledge. This study examines the functions of technology intermediaries from technological learning perspective along the five stages of the transfer process of demand articulation; market scanning, acquisition, assimilation and improvement. Building on present understanding on effective technology transfer and technological learning, this study suggests that four interrelated factors influence the functions of intermediaries along the transfer process. These are the proximity of intermediaries with users, specialization of intermediaries, characteristics of technologies and the capability of users. The functions of intermediaries along the five stages are examined in this study from the perspective of these factors, which are further defined and developed in Chapter 3 of the conceptual framework.

### ***1.5 RESEARCH OBJECTIVES AND QUESTIONS***

The central aim of this study involves identifying from user's perspective the different functions of intermediaries during the technology transfer process, the factors that influence those functions, and how they in turn influence user's learning within the context of firms in developing countries. In doing so, the study conceptualizes intermediaries as the main actors –supplier- along the transfer process, and analyses user's learning based on effective technology transfer from producer to users through intermediaries. Hence, the principal research question is:

- *How are technologies transferred from producers to end-users through technology intermediaries, and how do intermediaries influence users' learning?*

Three sub-questions were developed to guide answering the main question as follows:

- *What are the intermediation functions that different intermediaries perform along the inter-firm technology transfer process?*
- *What factors influence the functions of intermediaries along the transfer process? How do those factors influence users' learning?*
- *What are the implications for firm's learning when intermediaries transfer technologies?*

Given these research questions, the study aims to achieve the following research objectives:

- *Identify the principle functions of intermediaries in cross-national technology transfer from the perspective of a technological learning framework;*
- *Identify the primary factors that influence the functions of intermediaries along the transfer process;*
- *Examine how those factors might influence technological learning with local users;*
- *Develop a conceptual framework of key factors that influence the transfer process through intermediaries in cross-national technology transfer.*

## **1.6 RESEARCH DESIGN**

Due to the lack of sufficient prior research about the phenomenon being researched on this thesis, in addition to the exploratory nature of this research and the kind of research question established for this study (How), the study adopts a qualitative multiple case-based research method within the interpretive paradigm. The nature of this study suggests a process analysis that explores the technology transfer process at work (in practice) and seeks to explain 'how' the process in question takes place. The details of the research method are presented in Chapter 4 of this thesis. The cases selected for this study are the two main and large firms in the Omani oil and gas industry, PDO and OLNK. The selection of these firms is based on them being representative of firms with a weak internal R&D capacity and isolated from technological sources. Moreover, the two firms provide rich contents for this research in addition to being accessible and illuminative; thus they are seen as powerful examples for this study.

Interviewees were recruited from the two firms on a “snowball sampling” process. The process starts by identifying key informants at the two firms who in turn nominated the subsequent participants. The “saturation principle” (Mason, 2010) was employed to determine the total number of interviewees and the end of the data collection process for this study.

Empirical data was analysed interpretively through qualitative contents analysis (Holdford, 2008; Mayring, 2000; Miles and Huberman, 1994), in terms of what functions different intermediaries perform along the transfer process, what possible factors influence the different functions along the process, and how that might influence users’ learning. Following the suggestion of Eisenhardt (1989), the analysis of empirical data was conducted over two levels – within the cases and a comparison of results across the cases. The first level of analysis allowed for a deep understanding of each case individually, while the cross-case analysis allowed the comparisons of the results obtained from the two cases prior to establishing generalization (Eisenhardt, 1989). Influential factors were identified and refined deductively and inductively from the new data and prior results. Firstly, the data was reviewed in light of the existing framework in a deductive approach. An inductive approach was then employed to analyse data and identify new/emergent factors. Finally, based on the key findings, theoretical and practical contributions were drawn and presented.

### ***1.7 RESEARCH SIGNIFICANCE AND CONTRIBUTIONS***

The significance of this study is in providing a new and a better understanding of technology transfer and learning through intermediaries for firms in developing countries. While the existing studies focuses on examining technological learning through the direct producer-user relationship, this study examined learning through intermediary-users relationship. This is done by identifying the factors that influence the functions of intermediaries along the technology transfer, that in turn influence learning for firms with low internal technological capability and isolated from original sources of technologies. Inter-organizational technology transfer is “a complex phenomenon and in practice, successful transfer is often not easy to achieve” (Easterby-Smith *et al.*, 2008, p. 677). The existing understanding

of what contributes to successful inter-organizational technology transfer is still quite limited (Perez-Nordtvedt *et al.*, 2008). With the emergence of intermediaries, which are thought to hinder or eliminate direct interactions, the transfer and learning process requires further investigation.

This study brings theoretical and practical contributions. Theoretically, it adds to the literature of technological learning within developing countries by examining the technology transfer and learning via intermediaries instead of producers as the latter has been the focus of most previous studies. This study combines insights of two stand-alone literatures, technological learning and technology intermediaries, in order to provide a better understanding of the research problem. The combination of inputs from both literatures provides useful insights for understanding firms' learning and capability development through intermediaries. Through this combination, this study modifies the initial technological learning theory and provides a basis for future studies to better explain the process of technological learning through intermediaries. Moreover, while most studies on technology intermediaries do not explicitly adopt a theoretical framework for examining the functions of intermediaries, this study explicitly adopts the technological learning framework as a theoretical stance for examining those functions. Therefore, this study is a first of its kind that examines technology intermediaries from the perspective of technological learning framework, and identifies their functions and factors influence those functions on this theoretical stance.

Practically, this study enhances firms' understanding on factors that influence transfer and learning through intermediaries, which will help firms in selecting the best technology transfer partners – intermediaries. The present discussions on technology intermediaries focus on identifying the functions that different intermediaries perform (Kilelu *et al.*, 2011; Li-Ying, 2012). However, there is overlap in the functions performed by different intermediaries, making the selection of intermediaries for a technology transfer project difficult and complicated. By understanding the factors that influence the different functions of intermediaries and users' learning, managers and practitioners in the firms will be

better guided on how to select the appropriate intermediaries who will contribute to an effective transfer and firm's learning.

Specifically, this study contributes to the process of technological learning in a major sector of the Omani economy – oil and gas. This sector is the major economic player in the Sultanate of Oman and the major player in the inward technology transfer. The need to enhance and stimulate technological learning in the sector is crucial to sustain its development and enhance its competitiveness, which in turn will enhance the competitiveness of other sectors in the economy. Oman is a developing country with a weak R&D infrastructure and moderate technological capability (UNESCO, 2010). Technological learning is consequently based on successful technology transfer from suppliers (intermediaries). This basically means understanding the transfer process and the factors that might influence the process are crucial to achieve learning – competitiveness.

Overall, although the results of this study are based on the experiences of the Omani firms, results are expected to enrich overall understanding about firms in other sectors, and in other countries that have similar characteristics of weak internal R&D capacity and are isolated from technological sources.

### ***1.8 MAIN FINDINGS***

This study identified that intermediaries play key functions along the transfer process. They emerged along the transfer process, as some producers prefer to deal with them rather than dealing directly with end users. Accordingly, users realised that they need someone to compensate for the shortfall in technical support that would have traditionally been provided by the original producers of technology to the end users if they had acquired the technology directly. In the specific setting examined in the thesis, a clear division of labour was found in the functions performed by consultants and agents, as the two major intermediaries in the local market.

By analysing data of the two firms, this study identified the different functions that the two types of intermediaries perform along the transfer process. Moreover, this study found a set of five key factors influences the different functions of

intermediaries along the transfer process. Above all, these include the proximity between intermediaries and users, technical specialization of intermediaries, characteristics of technology being transferred, the capability of users, and the firm's technology strategy. The first four factors were initially proposed in the conceptual framework that was developed prior to the fieldwork, while the last factor emerged from the analysis of the empirical data. A thorough understanding of these factors is expected to allow local users to select the most appropriate intermediaries that might support effective transfer and learning. The details of these factors are presented in Chapters 6 and 7 of this thesis when discussing the findings.

The study also found that, those factors, while influence the functions of intermediaries, they also create a division of labour in the functions that different intermediaries perform. These factors highlight which type of intermediaries contributes towards firm's learning in comparison to other types. This helps firms in developing countries to select the right technology transfer partners (intermediaries) for their technology transfer projects.

## ***1.1 THESIS STRUCTURE***

In addition to this chapter, this thesis constitutes eight chapters as detailed in the following sections.

Chapter 2 is the literature review. It reviews studies on inter-firm technology transfer and technological learning with a focus on firms in developing countries. It also reviews studies on technology intermediaries along the technology transfer process. The chapter aims to develop a theoretical base of how firms might learn and develop technological capability through the technology transfer process and what factors influence transfer and learning. This review leads to question how the emergence of intermediaries might influence the existing understanding of technological learning. Moreover, the review aims to highlight the main theoretical and conceptual frameworks for understanding intermediaries in technology transfer. It identifies different types of intermediaries, their various functions and how they influence the transfer process. The final section of the chapter highlights the main gaps on which this study aims to contribute.

Chapters 3 and 4 present the details of the research design. Chapter 3 develops a conceptual framework of factors that are suggested to influence the functions of intermediaries during the transfer process. The factors are derived from the existing literature and the framework is intended to guide the deductive approach of the study. Chapter 4 presents the research method and justifies the adoption of a qualitative, comparative multiple site case study for this research. It explains how the analysis is implemented, going from data collection through to data analysis to answering the main research questions. The chapter also presents and discusses the various ethical considerations.

Chapter 5 presents background information about the settings of the cases selected for investigation. The chapter provides information about the Sultanate of Oman in general and the two cases, PDO and OLN, in particular. This chapter explains and justifies the selection of these firms. The information about the two firms focuses mainly on the status of science and technology, technology transfer practices, and the presence of technology intermediaries.

Chapter 6 presents a descriptive analysis of the empirical data gathered from the two firms. This chapter involves the within-case reports of the two cases. These reports are the first level for the qualitative data analysis, which pave the way for the theoretical analysis of the empirical data.

Chapter 7 presents a theoretical analysis of the empirical findings. This chapter revisits the technological learning and intermediary literature review to reflect on the findings and how they support or differ from previous studies, and why. This chapter also presents a new modified conceptual framework that includes the factors that were initially identified from the literature and that emerged from the data collection and analysis process.

Chapter 8 is the concluding part of the thesis. It briefly recapitulates the purposes of this study, the main theories and the research design used. It then presents the answers achieved by the study for the research questions initially posed, and how that was reached. The chapter also presents the main findings and contributions, theoretical and practical, and presents policy implications as have been learned from this study. The last section presents suggestions for future research.



## ***1.2 SUMMARY***

This chapter presented an overview of the thesis. The chapter started by exploring how technological learning theory understands learning during technology transfer. Previous research using this theory tends to assume learning goes through three stages and mainly occurs through direct producer-user interaction. As a result, little has been written on cases where technology intermediaries emerge between users and producers. The literature on technology intermediaries provides insights into the functions of different types of intermediaries during the transfer process, but does not yet adequately explain the factors that influence the different functions they undertake, nor how they influence the user's learning. As a result, technological learning through intermediaries remains poorly understood, which justifies further investigation, and highlights the gap in the literature that this study aims to contribute towards addressing.

## **2 TECHNOLOGY TRANSFER AND TECHNOLOGICAL LEARNING**

### ***2.1 INTRODUCTION***

As introduced in the previous chapter, this study examines how technologies are transferred from sources to recipients through intermediaries and how recipients develop internal technological capability about technologies through such technology transfer approach. In doing so, this study identifies the functions of intermediaries along the transfer process, explores factors that influence the functions of intermediaries and how those factors, in turn, influence the transfer and learning process with recipients in the context of developing countries. This chapter reviews the present relative literature to develop a theoretical basis for examining this process. The literature review links two bodies of literature – the literature on technology transfer and technological learning, and the literature on technology transfer intermediaries (TTI).

This literature review has two main objectives. It defines the theoretical foundation for the study and identifies knowledge gaps on existing literature that require further investigation. It is important to highlight the limited prior studies that have examined technology transfer and technological learning through intermediaries and precisely in the context of Oman where this study is implemented. Moreover, despite Oman being geographically isolated from most technological sources and possess weak technological capability, thus technology intermediaries are assumed to play significant roles in supporting the inward technology transfer and local learning, the functions of intermediaries and how they influence the local learning have not yet been subjected to scientific inquiry. For instance, no previous study has identified the different functions of intermediaries in the Omani context. Accordingly, the literature review will cover studies from geographic contexts other than Oman. Moreover, while the study examines the functions of technology intermediaries operating in the oil and gas industry, the literature review also draws on studies of intermediaries operating in other sectors, such as manufacturing or agricultural sectors, to gain understanding of intermediaries in different contexts.

To identify the relevant studies for the literature review, highly cited articles in both literatures were selected whenever possible and available. Additionally, the references listed in those articles were also identified and selectively reviewed in a snowballing process. The literature review focuses mainly on studies of firms in developing countries to highlight how such firms might learn and develop technological capability through technology transfer, and how the emergence of intermediaries might influence the transfer and learning. Insights from the experiences of firms in developed countries are also drawn from various studies. This chapter constitutes eight sections besides the introduction and summary.

## ***2.2 TECHNOLOGICAL LEARNING (TL) THROUGH TECHNOLOGY TRANSFER: AN OVERVIEW***

Firms strive to improve and sustain their competitiveness through developing different sets of capabilities, one of which is technological capability (TC) (Kim, 2001; Leonard-Barton, 1992). This capability is considered a key factor for generating technical change (Kim, 2001), and it is also essential for economic growth (Kim, 2001; Kumar *et al.*, 1999).

From a knowledge-based perspective, and based on the experience of Korean technological development, Kim (2001) defined TC as the “effective use of technological knowledge in production, engineering, and innovation in order to sustain competitiveness in price and quality” (Kim, 2001, p. 298). This definition emphasizes the importance of technological knowledge for the development of technological capability, for firms that initially lack technological capability. Moreover, it emphasizes not only possessing the knowledge, but also the ability to employ knowledge to sustain competitiveness. Therefore, the process of developing technological capability requires access to technological knowledge, which can be accessed from internal sources of the firm or acquired from external sources (Malerba, 2002).

According to Lall (1992) and Viotti (2002,2003), TC enhances a country’s technological development through allowing firms to master new technologies, adapt them to local conditions, improve upon them, diffuse them within the

economy, and finally produce alternatives (Lall, 1992; Viotti, 2002). Functionally, technological capability is categorized into three main levels, namely operation and production, improvement, and innovation (Viotti, 2002). The development of technological capability is accumulative in nature, and starts from simple operation and imitation capability through to innovation capability (Bell and Pavitt, 1993; Kim, 1997).

TC is developed through a process of technological learning (Kim, 2001; Lall, 1992) that involves different efforts of education, practice and training, in addition to the allocation of resources (Bell and Pavitt, 1993; Lall, 1992). According to Kim (1999), technological learning is mainly based on the effective applications of technological knowledge. However, most firms in developing countries do not possess adequate internal knowledge production capacity such as an R&D capability (Bell and Pavitt, 1993; Viotti, 2002), and hence access technological knowledge from external sources (Malerba, 1992), mostly through a technology transfer process (Kumar *et al.*, 1999). It has been recognized that most firms in developing countries start their technological learning with little or weak initial technological capability, and gradually develop capability as they transfer technologies from external sources (Figueiredo, 2003).

However, despite the significance of technology transfer processes for technological learning, several experiences have shown that not all processes lead to learning and capability development (Kumar *et al.*, 1999; Lin, 2003; Ngoc Ca, 1999). It was reported that, although technology transfer is a necessary condition for firms' learning in developing countries, it is not sufficient (Bell and Pavitt, 1993). Technological learning does not occur as an automatic result of technology transfer or as a by-product to the transfer process itself (*ibid*). Instead, it requires the recipients to develop initial learning capability prior to transferring technologies from external sources. This capability is widely known as "absorptive capacity" (Cohen and Levinthal, 1990; Kim, 1999), which largely determines the degree of learning from external sources. This capacity reflects the firm's ability to recognize the value of new external information, assimilate it, and apply it to commercial ends – innovation (Cohen and Levinthal, 1990). The absorptive capacity is a function of prior related knowledge and intensity of efforts for

learning (*ibid*). While prior knowledge with most firms in developed countries is generated and accumulated by learning through R&D activities (Cohen and Levinthal, 1990), it is through the different efforts of learning-by-using with most firms in developing countries (Bell and Pavitt, 1993; Kim, 1999).

Equally to the absorptive capacity of recipients, technological learning from external sources requires a supplier capable of communicating and articulating external technologies to a level that can be absorbed and understood by different recipients (Minbaeva, 2007). Different terminologies have been used interchangeably to describe this capacity of suppliers such as “transmissive capacity” (Husman, 2001); “disseminative capacity” (Minbaeva and Michailova, 2004; Mu *et al.*, 2010; Park *et al.*, 2013), or “tutoring capability” (Cyhn, 2002).

However, since learning with most firms in developing countries is largely based on technologies being transferred from external sources, and that not all transfer processes lead to learning, it is, therefore, crucial to first understand the characteristics of the technology transfer process that might lead to learning and capability development. This is discussed and reviewed in the following section.

### ***2.3 TECHNOLOGY TRANSFER: NEOCLASSICAL VIEW VERSUS THE KNOWLEDGE BASED VIEW (KBV)***

The previous section highlighted that technological learning with most firms in developing countries is mainly based on transferring and absorbing technologies from external sources. However, it has been also found that not all transfer processes lead to learning at the recipient sides (Bell and Pavitt, 1993; Kumar *et al.*, 1999). So how and when technology transfer leads to learning requires clarification.

There are two main schools of thought that provide different understandings of technologies and their transferability for learning. These are the neoclassical view (Purvis, 1976; Romer, 1990), and the knowledge-based view (KBV) (Grant, 1996; Kim and Nelson, 2000; Kogut and Zander, 1993; Lall, 1992). The two views differ in the way they define technologies, thus their transferability.

The neoclassical view perceives technologies as a commodity or technique that are easily replicated and transferred from one point to another (Lin, 2003). Based on this view, technology is treated as a physical object, and thus an effective transfer is mainly the transfer of the physical technology. Accordingly, technology can be detached from its sources and can be easily transferred to other places without great effort from the recipient sides to absorb technologies (Lall, 1992). This theory emphasises the role of knowledge codification and assumes technological knowledge is codified and transferred to users with the physical object of technology. Nelson and Pack (1999) call the neoclassical view the “accumulation” view (Kim and Nelson, 2000), since it emphasises the accumulation of physical technologies for technological learning.

The ultimate goal of technology transfer – based on the neoclassical view – is to use technologies mainly for the applications they were initially imported for such as to enhance the local production system and/or to exploit more resources (Cyhn, 2002; Kumar *et al.*, 1999). This goal of the transfer process has significant policy implications for a country that relies on external sources of technologies. As Bell and Pavitt (1993) and Lall (1992) highlighted, this ultimate aim of the transfer process steers the local efforts to purchasing technologies rather than developing indigenous technological efforts to achieve growth. The neoclassical view does not emphasize the significance of local efforts to absorb and internalize external technologies. Instead, it assumes accessing external sources is always possible and equal for all users (Lall, 1992), whenever needed.

However, the neoclassical view ignores several issues that might influence learning during the transfer process. For instance, the theory does not clearly consider how the characteristics of technologies – such as being complex or novel or even requiring extensive tacit knowledge – influence its transferability. In addition, this theory implicitly assumes the sources of technology are capable and willing to codify and transfer technological knowledge to recipients. Moreover, since technology is perceived as a physical commodity that is easily detached from its source, the neoclassical view assumes no need for direct producer-user interactions to achieve effective transfer.

In contrast to the neoclassical view, the knowledge-based view (KBV) approach technology transfer as a knowledge transfer process. Technologies to this view constitute two elements: a physical object and technological knowledge (Kumar *et al.*, 1999; Lall, 1992). Accordingly, effective technology transfer includes the transfer of both elements from their sources to recipients. Based on the KBV, the technological knowledge associated with the technologies must be transferred completely from equipment supplier to engineers and operators of the user firm to effectively utilize the equipment

According to the KBV, knowledge does not drive firms' technological learning (Lall, 1992), but importantly it is the strategic source of firms' competitiveness (Grant, 1996). For instance, Lall (1992) argues that knowledge is the essence of technological learning, and a successful technology transfer includes the transfer of a physical object and associated technological knowledge (Sazali and Rose, 2011). As per Amesse and Cohendet (2001), the KBV has shifted the conventional understanding of technology transfer as being mainly the transfer of physical commodity to a knowledge transfer process (Amesse and Cohendet, 2001; Kumar *et al.*, 1999).

Knowledge can be divided to codified and tacit (Nonaka and Krogh, 2009; Polanyi, 1966). Codified knowledge is characterised as being easily expressed and articulated, can be detached from its source, and is shared and transferred in formal language (Hislop, 2009), for example, in publications such as books, articles, manuals, and formulas. However, it has been found that, technology transfer that transfers only the codified knowledge limits learning to the development of the simplest level of learning and capability development – operation capability (Kumar *et al.*, 1999). In contrast, tacit knowledge is the knowledge that is not easily articulated or communicated, nontangible, sticks to its source (Simonin, 1999; Szulanski, 1996) and is personal and context specific (Hislop, 2009). While KBV argues that, learning occurs mainly through the conversion and interactions between tacit and codified knowledge (Nonaka and Krogh, 2009), the knowledge that mainly drives technological learning is the tacit (Lall, 1992). Due to its sticky nature, the transfer of tacit technologies requires the direct source-recipient interactions at the individual level (Cyhn, 2002; Grant,

1996). Hence, based on the KBV, effective technology transfer focuses primarily on transferring knowledge in a human-oriented process involving interactions between individuals from sources and recipients (Grant, 1996).

It is a fact that most developing countries transfer technologies from external sources. Although these technologies are employed to extract more resources and enhance productivity to achieve economic growth, they can be also utilized to develop indigenous technological capability (Kumar *et al.*, 1999). Accordingly, the perception of the KBV on technologies, that stresses the transfer of technological knowledge (besides the physical object) is the most related for these firms, as it emphasises the indigenous efforts needed for internalizing external technologies (Lall, 1992).

However, as highlighted earlier, the effectiveness of technology transfer and learning from external sources is influenced by several factors. The initial conceptual and empirical studies on technology transfer for developing countries focused on firm's absorptive capacity as a major influential factor on the effectiveness of the transfer and learning (e.g. Bell and Pavitt, 1993; Dahlman *et al.*, 1987; Figueiredo, 2001; Kim, 1999; Viotti, 2002). Importantly, these studies have shifted the traditional analysis of absorptive capacity from R&D-based (Cohen and Levinthal, 1990; Mowery and Oxley, 1995), to the intensity of various efforts of learning such as training and learning by using, to internalize external technologies.

Since learning is mainly based on absorbing technologies being transferred from external sources, other studies highlighted the influences of suppliers of technologies in terms of their capability to engage in effective transfer to support the recipient's absorption of technologies (Cyhn, 2002; Minbaeva and Michailova, 2004; Mu *et al.*, 2010). These studies argue that, for effective transfer, suppliers support recipient's learning through various functions such as training, human resource movement, and demonstration of operation of technologies.

As technologies are the subject for learning, the different characteristics of technologies, including the tacitness, technical complexity and novelty, were also highlighted to influence the transfer and learning process (Cyhn, 2002; Easterby-



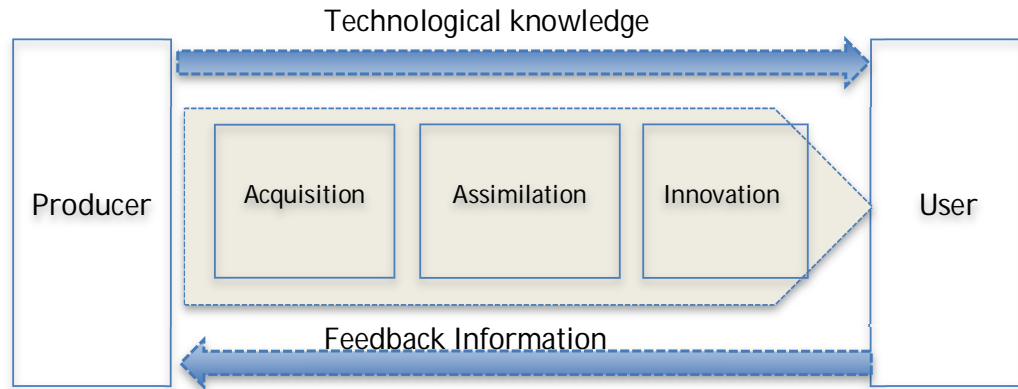
Smith *et al.*, 2008; Simonin, 1999; Zander and Kogut, 1995). These characteristics were found to influence the ability of suppliers to articulate and communicate technologies and the ability of users to absorb and internalize them.

In addition, effective transfer of technologies was also found to be influenced by how close the sources and recipients were to each other – i.e. their geographical and cognitive closeness - proximity (Boschma, 2005; Woerter, 2012). Several studies argue that differences in the level of technological capability between sources and recipients directly influence the effectiveness of the transfer. Equally, the difference in geographical location and the distance between sources and recipients might negatively influence the ease of communication and interactions. The influences of these factors on the transfer and learning process are discussed in the following sections.

## ***2.4 TECHNOLOGICAL LEARNING: THE PROCESS***

The previous section recognized that technology transfer is a process of technological learning for developing technological capability, and requires different efforts and resources from the source and recipients (Bell and Pavitt, 1993). Moreover, besides the need for the physical technologies to drive learning, technological learning is largely based on transferring and absorbing tacit knowledge that requires direct interactions with its source (Grant, 1996; Lall, 1992). Based on the experience of S. Korean in learning from technologies being transferred from Japan, Kim (1980) developed a theory of technological learning via the technology transfer process involving a sequence of three stages: namely acquisition, assimilation, and innovation (Kim, 1999), as illustrated in Figure 2-1 below.

**Figure 2-1 Technological Learning via Technology Transfer Process: the Conventional Technological Learning Theory**



Source: Compiled and developed by the author of this thesis

Kim (1999) explained the process of learning through the three stages as follows:

1. *Acquisition of mature (packed) technology*: at the initial stage, firms acquire mature technologies from developed countries. Technologies include assembly processes, product specifications, production know-how, technical personnel, and components and parts. This develops production technological capability.
2. *Assimilation*: after technologies are acquired, firms integrate the external technologies with the internal system. This is enhanced by intensive learning efforts in order to produce differentiated products – improvement technological capability
3. *Improvement/innovation*: The assimilation process, enhanced by advance capability of local scientific and engineering personnel, leads to duplicative imitation, producing duplications of the original technologies – innovation capability

Implicitly, the present technological learning theory is based on three principal assumptions. First, technologies are acquired from their original sources – producers. Second, there are direct producer-user interactions. Third, learning starts at the acquisition stage of external technologies. These assumptions are inferred from the analysis of technological learning in different contexts and firms (e.g. Cyhn, 2002; Easterby-Smith *et al.*, 2008; Figueiredo, 2003; Kim, 1999, 1980; Mu *et al.*, 2010; Viotti, 2002).

The acquisition of mature technologies from their original source suggests that the source is knowledgeable enough to support the user's absorption and internalization of technologies. Accordingly, the direct interactions with knowledgeable sources allow for the direct flow of technological knowledge from source to recipients through which suppliers articulate, simplify and communicate technologies to a level understood by recipients (Minbaeva and Michailova, 2004; Szulanski, 1996). The direct interactions with suppliers allows recipients to absorb technological knowledge and provide direct feedback about the technologies being transferred (Leonard-Barton, 1992; Lim, 2005). Moreover, the direct interactions allow for learning through demonstrations of the principles and operation of technologies (Cyhn, 2002; Mowery and Oxley, 1995), or through the movements of experienced personnel from suppliers to users (Cyhn, 2002; Lim, 2005).

Moreover, starting the process of learning at the acquisition stage of mature technologies from external sources implicitly suggests that recipient firms are capable of identifying their internal demands for external technologies, of identifying the sources of external technologies and of assessing the various options of technologies (market scanning) to select the most compatible. However, as Figueiredo (2001) highlighted, most firms in developing countries start technology transfer with weak or no technological capability, and they develop them through different efforts along the transfer process. The existing technological learning theory does not clearly explain how such firms recognize their internal needs for external technologies, let alone how they assess various options of technologies. In the lack of internal capability to identify demands, firms in developing countries might end up transferring technologies that do not respond to internal demands or solve internal problem, thus learning might not be achieved.

Therefore, technological learning from external sources requires the ability to recognize and articulate internal demands and the ability to scan the technology market to identify technologies that will meet those demands. Accordingly, this study argues that, technological learning with most firms in developing countries starts at the internal demand articulation and market scanning stage, to identify a range of options, assess them and finally select the most suitable.

Since tacit technological knowledge was recognised as the locus for learning (Lall, 1992), and it requires direct interactions with its source for its transfer (Cyhn, 2002; Grant, 1996), an effective acquisition process for learning typically involves direct supplier-user interaction. This direct interactions enhance the transfer and absorption of technological knowledge through the demonstration of operation and of various functionalities of technologies being transferred (Cyhn, 2002; Mowery and Oxley, 1995), and simplifying the complex technologies to a level understood by recipients (Minbaeva, 2007). Without such direct interactions, users run the risk of transferring only the physical technologies or the codified knowledge, which is thought not to contribute significantly towards developing advanced technological capabilities, including improvements and innovation capability (Cyhn, 2002).

However, acquiring or possessing external technologies is not sufficient for firms' learning if that knowledge is not assimilated - internalised (retained) and combined with internal knowledge system (Szulanski, 1996; Zahra and George, 2002). Consequently, the acquisition stage is followed by the assimilation and transformation of technologies. Assimilation refers to the firm's efforts and activities that allow analysing, processing, interpreting and understanding of the technology and knowledge obtained from external sources and integrate that with the internal systems (Zahra and George, 2002). As Lin (2003) argued, learning occurs only when firms internalize external technologies after they have been transferred.

According to Nonaka and Krogh (2009), technology assimilation is the knowledge conversion processes by which firms learn through converting external knowledge from tacit to codified (knowledge codification), and combine it with internal system (internalization). The nature of technologies that is acquired through the direct interactions with suppliers is often tacit. Users codify that by translating, simplifying or interpreting the tacit knowledge in order to put it into practice and integrate it with the firm's internal knowledge (Nonaka and Krogh, 2009). The assimilation stage aims mainly at retaining external knowledge within the firm and enhancing and monitoring its continuous use (Szulanski, 1996). The assimilation stage of external technologies allows firms to adapt technologies to different

contexts, translate external technologies into organizational language, and integrate technologies with the internal system to enhance its efficiency. In addition to the efforts of learning-by-doing at this stage, learning is sometimes partially supported by internal R&D activities (Dantas and Bell, 2011; Viotti, 2002); that aims at adaptation or improvements of functionalities of technologies.

The last stage of TL is the improvement (value addition) technologies being transferred – innovation (Kim, 1999; Zahra and George, 2002). By this stage, which comes as a result of a successful accumulation of the last stages, firms are able to create and carry out innovation from the concept to economic practice (Kim, 1997). Firms at this stage do not only operate or improve the functionalities of the transferred technologies but are also capable of producing alternatives with similar or new functionalities. To be more precise, firms progress from the imitation stage, that is based on operation and improvement capability, to the innovation stage that is largely based on R&D activities (Kim, 1997; Dantas and Bell, 2011). Learning at this stage occurs through improving the internal system and generating commercial applications to the integrated external with internal technologies (Cohen and Levinthal, 1990).

## ***2.5 TECHNOLOGICAL LEARNING THEORY: REFLECTIONS AND GAPS***

Although technological learning theory (Kim, 1999, 1980; Lall, 1992; Viotti, 2002) was proposed and developed based on the experiences of firms' learning within the context of developing countries that lack originally internal R&D capacity, and which in many cases are geographically isolated from original sources of technologies, this study believes that the theory still suffer from certain limitations. First, the theory assumes technological learning via technology transfer goes through a sequence of three key stages, and that learning starts after the acquisition step of external technologies. For instance, Kim (1980, 1999) analysed technological learning within Korean firms in the electronic industry from the acquisition stage of external technologies. Likewise, Lin (2003) claimed that firms start learning by internalizing external technologies after they are acquired from their sources. However, inadequate explanation has been offered for the tasks that

occur prior to the acquisition stage, such as demand articulation or market scanning.

Prior research has emphasized both stages of the demand articulation and market scanning for effective technology transfer. For instance, Szulanski (1996) argued that the internal demand identification should trigger the search process for external technologies. Equally, Ramanathan (2002) argued that matching internal demands with external technologies prior to initiating the transfer is the first step in ensuring a successful technology transfer, especially for firms in developing countries. The matching process is expected to be difficult if firms cannot identify the internal demands and identify external sources that meet the demands prior to transferring external technologies. Likewise, Andersson (2009) argued that a technology transfer that is initiated without understanding the internal demands is deemed to fail and might not contribute to learning (Andersson, 2009). However, as Boon *et al.* (2008) noted, despite the significance of the demand recognition and articulation process for the success of technology transfer and learning, previous studies have been silent about it, whether it occurs and what its dynamics are.

Linked to demand articulation is the firm's capability to scan the market in order to identify various options of external technologies, and the ability to assess those options to select the most compatible options (Bessant and Rush, 1995). The success of technology transfer from external sources involves the capability of identifying external options and assessing them to select the option that matches with the internal system in order to ensure a successful integration between external and internal systems.

However, despite the significance of demand articulation and market scanning, technological learning theory does not address them adequately or explain whether suppliers or recipients perform these two stages or how they are performed. Therefore, based on the above explanation and discussion, this study argues that effective technology transfer involves two additional stages prior to the three stages that were highlighted in technological learning theory.

The demand articulation and market scanning stages have been discussed more explicitly in the context of technology transfer in developed countries. For

instance, Cohen and Levinthal (1990) coined the term “absorptive capacity” for firms’ ability to identify internal demands for external technologies and recognize the value of external technologies. Accordingly, they defined the absorptive capacity as the ability of the firm to “recognise the value of new, external information, assimilate it, and apply it to commercial ends” (Cohen and Levinthal, 1990, p. 128). The authors emphasized the ability of firms to recognize the value of external technologies, which include the ability to identify internal demands, and identify options and assess them to select the best. Similarly, within the context of intra-firm transfer of best practice, Szulanski (1996) argues that the process of technology transfer starts by the recognition of internal demands for external technologies.

The significance of the two above mentioned stages (demand articulation and market scanning) for firms’ learning have been also emphasised in the context of oil and gas industry – Low to medium technology industry. This is discussed in the following section.

## ***2.6 INNOVATION (TECHNOLOGICAL LEARNING) IN LOW-MEDIUM TECHNOLOGY INDUSTRY***

In his seminal taxonomy, Pavitt (1984) identified the sources of innovation for different industries in what he called pattern of technical change. According to Tunzelmann and Acha (2005), the oil and gas industry falls within the low to medium technology industry. According to the taxonomy, this is a sector for industries that are frequently “mature”, where technologies and market conditions “may change more slowly”. Technological learning in such an industry is driven largely by diffusing and using technologies produced elsewhere, rather than in the production of new technologies (Robertson et al., 2009). It is therefore in the process of diffusion and adaptation of external technologies to internal use that most learning takes place. The key factor in firm learning is the firm’s internal ability to identify technologies from external sources and to recognise their values for their internal use – the firm’s absorptive capacity (Cohen and Liventhal, 1990). This made the process of searching for new knowledge, identification and proof,

besides the adaptation ability are of particular importance to learning and innovation in this industry (Von Tunzelmann and Acha, 2005).

Within the context of oil and gas industry (supplier dominated innovation), technology suppliers have been found to play a key function in the sector. The focus here is on process rather than product innovations, and innovation is mainly related to production engineering, supported by capital goods provision from specialist suppliers. Learning and innovation therefore involves incorporation of high-tech components, produced mainly by specialised suppliers, into existing products and production processes. These suppliers play key roles in generating associated innovations with their customers and diffusing new innovations globally. The industry therefore involves large, scale-intensive firms, and smaller highly technically sophisticated suppliers (who may themselves be large firms operating on a global scale). Diffusion of technologies and learning with recipient firms are assumed to occur mainly through the direct producer-user relationship, through which advanced technologies are diffused and adapted for end users.

Pavitt's (1984) taxonomy implies an over simplification for the learning that takes place in a country such as Oman (and other countries geographically isolated from specialized suppliers), where technology intermediaries and agents mediate the relationship between scale-intensive operators and technically sophisticated capital goods specialised suppliers. Where knowledgeable specialized suppliers exist, some technological knowledge can then diffuse to local users through the coordinated efforts of actors. For example, producers can support knowledge transfer and user learning by demonstrating the different functions of technologies being transferred (Cyhn, 2002), or through the movement of expertise and by interacting with individual users (Cyhn, 2002; Figueiredo, 2003). In addition, producers can also support user learning through simplifying, articulating and communicating tacit or complex technologies to a level understood by different individuals in the interacting firms (Minbaeva and Michailova, 2004; Mu *et al.*, 2010). Where direct producer-user interactions occur, the firm's internal capability to recognise and internalise external technologies play a key role on learning. In the absence of specialised suppliers, the concern remains whether intermediaries can support users learning and how. It has been emphasised that,



developing and maintaining searching capability as well as the ability to adapt them to internal use is expensive (Leonard-Barton, 1984; Cohen and Leventhal, 1990). This has made different firms reliant on technological intermediaries. Therefore, innovation and learning in the low and medium technology industries (such as the oil and gas industry) in many developing countries may be less a function of identifying, diffusing and adapting external technologies as they mostly lack such capability, and depend more on the ability of intermediaries to support the process.

These different functions of suppliers in supporting user learning are all based on the assumption that producers are capable and knowledgeable about technologies being transferred (Capannelli, 2001; Szulanski, 1996). However, where technologies are acquired through intermediaries, and to what extent they are able to substitute specialized producers in the diffusion of technologies remains poorly explained. Accepting that technology intermediaries are capable of transferring the physical object of technologies from suppliers to recipients, their capability to transfer technological knowledge and drive technological learning efforts requires further investigation. The question of “knowledgeable suppliers” is therefore critical and directly impacts the functions of intermediaries on the transfer and learning, especially for firms in developing nations. A technology transfer process through intermediaries might go through multiple transfer processes in which multiple intermediaries are involved along the transfer process from producers to recipients. Multiple intermediaries might mean that the transfer process does not go in a direct one-to-one-to-one (producer-intermediary-user) transfer process, but instead goes from one-to-many-to-many/one (producer-intermediaries-users) (Howells, 2006; Leonard-Barton, 1984).

In order to better understand the influences of intermediaries on the transfer and learning process, the following section reviews the emergence of intermediaries and their different functions along the various stages of the technology transfer process.

## ***2.7 TECHNOLOGY INTERMEDIARIES: AN INTRODUCTION***

Previous sections have highlighted the lack of adequate understanding provided by existing technological learning theory on the emergence of intermediaries along the technology transfer process, and how they might influence the recipients' learning. This section aims to review and identify how intermediaries might influence the process through their different functions. However, prior to reviewing and presenting the various functions of intermediaries along the transfer process, it is essential to define technology intermediaries, how they emerge, and how they differ from the original suppliers.

As noted previously, the conventional technology transfer approach in the oil and gas industry is implemented through the direct relationship between the specialized suppliers and operators. However, the effectiveness of the direct relationship is conditioned by several factors such as the proximity between source and recipients, technological gap between them, prior knowledge with recipients, and the characteristics of technologies in terms of tacitness, complexity and novelty. Nonetheless, direct relationships may not always be possible or desirable for firms in developing countries. Such firms possess weak technological capability (Figueiredo, 2001), lack knowledge production capacity in terms of R&D (Bell and Pavitt, 1993; Kumar *et al.*, 1999), and, in most cases, are isolated from original sources of technologies (Hobday, 1995; Lall, 1990).

In addition, there are several transaction costs associated with the technology transfer processes (Tietze and Herstatt, 2010) that, due to lack of capability, many firms in developing countries will find difficult to address. These include –but not limited to– the cost associated of identifying sources of technologies, assessing the suitability of the various options, or negotiating the deal with different sources, and supervising the transfer process. Also, some firms intentionally aim to outsource some of their secondary tasks to external service providers (Howells, 2006). These conditions create a geographical and cognitive gap between sources and recipients in developing countries, making transferring technologies from developed to developing countries complex and difficult.

To support inward technology transfer in such circumstances, firms follow a range of different approaches to ease some of the difficulties. These approaches include

such as entering into strategic alliances with more technologically advanced firms (Intarakumnerd and Chaoroenporn, 2013), establishing linkages with local and foreign universities and research centres, sending personnel for education and training, and attending technical workshops and gatherings (Kumar et al., 1999; Viotti, 2002). In addition, there is a tendency with some firms to recruit intermediaries to provide different functions that support the inward technology transfer (Bessant and Rush, 1995; Li-Ying, 2012). Therefore, internal and external factors to the recipients have led to the emergence of intermediaries along the transfer process.

Technology intermediaries have been studied in different literatures. However, despite the ample research, the literature on technology intermediaries is quite fragmented, leading to what Howells (2006) highlighted as a scattered field of study that is "not well grounded theoretically" (p. 718). In his seminal work that synthesized the literature around intermediaries, Howells (2006) highlighted that interests in intermediaries have emerged from four main bodies of literature. These include literature on technology transfer and diffusion (e.g. Leonard-Barton, 1984), innovation management (e.g. Howells, 2006), networking and knowledge service (e.g. Bessant and Rush, 1995). Across the different literatures, different types of intermediaries have been identified such as innovation intermediaries (Howells, 2006), diffusion intermediaries (Leonard-Barton, 1984), consultants (Bessant and Rush, 1995), brokers (Kilelu *et al.*, 2011), and technology agents (Li-Ying, 2012; Shohet and Prevezer, 1996).

Due to the lack of theoretical groundedness (Howells, 2006), or the contextual nature of intermediaries (Clarke and Ramirez, 2013), a clear definition of intermediaries has not yet been developed thus various terminologies are being used interchangeably. Previous studies failed to offer definitions for each type of intermediary or the characteristics that distinguish one type from another. This makes it hard to distinguish types of intermediary based on their names or definitions.

Furthermore, previous studies have often adopted a functional-based definition for intermediaries – where the name is derived from the functions performed by

intermediaries. For instance, Leonard-Barton (1984) examined the role of intermediaries in diffusing innovation to less capable users and called that type of intermediary a 'diffusion intermediary'. Likewise, Bessant and Rush (1995) examined the role of intermediaries in advising users and called this type of intermediary a 'consultant'. Similarly, Howells (2006) examined intermediaries along the UK-linear innovation process and called them 'innovation intermediaries'. However, there are overlaps in the functions performed by different types of intermediary, making a functional-based definition of intermediaries quite misleading (Kilelu *et al.*, 2011).

This study will examine functions of technology intermediaries from the perspective of a modified technological learning framework that constitutes five stages of learning, from demand articulation through to innovation. The original framework of technological learning considers that the technology transfer process constitutes three stages, namely acquisition, assimilation and improvement. The modified framework adopted in this study adds two further stages; specifically demand articulation and market scanning, as essential stages that come before the actual acquisition. In particular, this study focuses on identifying the different functions performed by intermediaries and will explore the factors that influence those functions, and how those factors might influence users' learning. Based on the above discussion and the objectives of this study, technology intermediaries are defined in this study as:

*"Organisations or individuals that are engaged in any stage of the inter-firm technology transfer processes between suppliers and end-users, and perform a variety of intermediation functions to support users along the different stages of technology transfer"*

Intermediaries and user firms of this study are located in the Sultanate of Oman, which is a technologically lagging country (TRC, 2010; UNESCO, 2010). The firms have no internal R&D capability (R&D department or dedicated scientists and researchers), and their technological learning goes alongside technology transfer supported by various efforts of education and training to support inward

technology transfer. Within this context, the functions of intermediaries, and the factors that influence their functions as direct suppliers, are examined.

## ***2.8 TECHNOLOGY TRANSFER THROUGH TECHNOLOGY INTERMEDIARIES***

The previous sections have established that intermediaries have become one of the key actors in technology transfer especially for firms in developing countries. They dominate several tasks along the transfer process that are especially important for firms isolated from technological sources. Moreover, prior studies on technology intermediaries highlighted that intermediaries often dominate two main functions during technology transfer – demand articulation and market scanning (Howells, 2006).

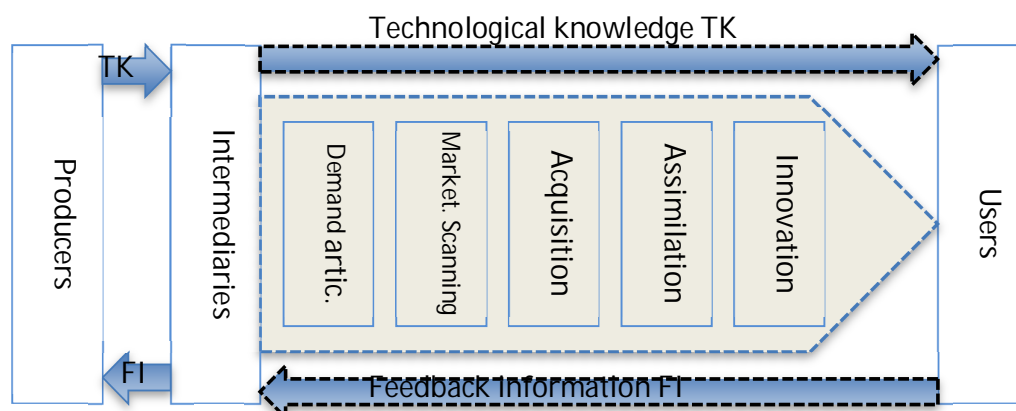
The first stage in an effective transfer process is internal demand articulation (Bessant and Rush, 1995), and according to Szulanski (1996) it triggers the search process for external technologies. This stage involves several activities that aim at identifying the internal demands for external technologies through defining problems being faced or exploring opportunities to improve the operation. Moreover, this stage sets standards and specifications for external technologies that might respond to internal demands. This stage is then followed by the second stage - market scanning (Bessant and Rush, 1995). Howells (2006) called this stage, “scanning and technology intelligence”, and suggests it involves information processing such as simplifying and interpreting of information associated with technologies. Information processing aims at supporting the users in the adoption decision. Accordingly, market scanning includes identifying a range of technological options and their sources, assessing the different options, processing the information related to options, and finally selecting the option that best matches the specific requirements (Bessant and Rush, 1995; Clarke and Ramirez, 2013; Howells, 2006).

As highlighted above, these two stages are crucial in any effective technology transfer for technological learning. It is noted that when users do not possess the capability to define or specify demands, or are incapable of identifying external

options, they seek assistance from technology intermediaries (Bessant and Rush, 1995; Dahlman *et al.*, 1987). According to Howells (2006), these two stages have been considered in previous studies as the “primary role of intermediaries”. While all intermediaries perform either or both of these functions, not all were found involved in the remaining three stages of technology transfer in order to support long-term learning. For instance, the industrial survey that was conducted to identify the roles of intermediaries in UK technology transfer found almost all intermediaries are involved in enhancing the users’ accessibility (market scanning) to technologies, but not all provide technical expertise, and only one-third offered post-transfer support (Seaton and Cordey-Hayes, 1993). Likewise, Shohet and Prevezer (1996), and Li-Yin (2012), found technology agents are not involved in the actual knowledge transfer or post-transfer technical support. Instead their role is mainly limited to link users with producers of technologies. However, it is not adequately explained what factors make an intermediary perform a certain function along the transfer process.

Based on the above discussion, this study combines the two stages of demand articulation and market scanning with the initial model of technological learning. The study intends to examine the functions of intermediaries along the five stages of the transfer process. Accordingly, a modified model of inter-firm technology transfer and technological learning is presented in this study, as shown in Figure 2-2.

**Figure 2-2 Technological Learning via Technology Transfer: a Modified Framework**



Source: Author modification of the original technological learning framework

The modified framework constitutes five main stages of technology transfer. It combines the three stages initially defined in Kim (1980) and adopted by many others (e.g. Dahlman *et al.*, 1987; Figueiredo, 2001; Lall, 1992; Viotti, 2002), with the two stages of demand articulation and market scanning as highlighted (Bessant and Rush, 1995; Howells, 2006). This modification is supported by other studies conducted for intermediaries in the context of developed countries. For instance, Bessant and Rush (1995) argued that an effective technology transfer involves five key stages, specifically the recognition of opportunities or demands, market scanning and assessment, acquisition, assimilation, and long-term learning. Bessant and Rush (1995) emphasised the significance of the five stages for long-term learning, which occurs as a result to the successful execution of the all stages. While the study of Bessant and Rush (1995) highlighted these stages and examined the various roles of intermediaries along the five stages, the study did not adequately explain the factors that influence the different functions of intermediaries along the five stages. Importantly, that study was based on the experience of intermediaries in the UK innovation system where all actors are located within the same system. Whether the results achieved on examining the functions of intermediaries in advanced countries are similarly applicable to that in developing countries are still not adequately investigated.

This study will examine technology transfer and learning through the framework presented in Figure 2-2, to identify the various functions of intermediaries along the five stages of the transfer process, and what factors influence how they carry out those functions.

Having discussed the basis upon which technology intermediates are examined, the following sections review studies on technology intermediaries to identify the different functions that different intermediaries perform along the five stages.

## **2.9 TECHNOLOGY INTERMEDIARIES: INTERMEDIATION FUNCTIONS ALONG THE TRANSFER PROCESS**

The previous sections have established that effective technology transfer for technological learning via technology transfer goes through a sequence of five

stages (Bessant and Rush, 1995). Each stage constitutes several intermediation functions and requires different transfer and learning capabilities. Moreover, it was noted that different types of intermediary perform different functions along the technology transfer process (Bessant and Rush, 1995; Howells, 2006). Some types of intermediary perform more than one function (Howells, 2006), or move from one function to another as per market needs (Tietze, 2010). The different functions of intermediaries along the five stages of the transfer process are reviewed in the following sections.

### **2.9.1 DEMAND ARTICULATION**

This stage is the first step in any successful technology transfer process (Bessant and Rush, 1995), as it triggers the search process for external technologies (Szulanski, 1996). It aims at recognizing internal demands for external technologies prior to importing them. This stage is often implemented through different approaches such as problem-solving or needs-analysis sessions (Bessant and Rush, 1995; Kilelu *et al.*, 2011), strategic planning and foresight (Bessant and Rush, 1995), as well as technology forecasting or technology road mapping (Howells, 2006). This stage leads to defining the problems of the system that need to be addressed, or the opportunities to be captured, in addition to defining the specifications of the external technologies that are required to meet internal demands.

Previous studies reported that not all intermediaries are involved with users for demand articulation. For instance, Shohet and Prevezer (1996) found technology transfer agents are not involved in the demand articulation of users of technologies. By contrast to that, Leonard-Barton (1984) found diffusion intermediaries are heavily involved in the demand articulation for low capable users, and accordingly are able to advise on the suitable technologies. A similar result was found for technology agents operate across the China-European technology transfer framework (Li-Yin, 2012). By contrast to that, in examining the functions of consultants in the UK's Enterprise Initiative, Bessant and Rush (1995) found consultants are involved with the SME at the demand articulation or problem definition stages. The Enterprise counsellor (consultant) works with SMEs to identify and articulate their demands or challenges and suggest potential



solutions to overcome them. The authors called this role a “diagnostic” role, in an analogy to general medical practitioners who diagnose patients and prescribe medicine for treatment. Even when clients (recipients) are not able to identify their demands, consultants help in articulating those demands.

In the study about the function of innovation intermediaries along the UK-linear innovation system, Howells (2006) found innovation intermediaries support the process at this stage through their foresight and diagnostic functions. For instance, Howells (2006) noted, organisations such as CERAM and SIRA that act as consultants provide, respectively, technology forecasting and technology road mapping (TRM) services. Through these functions, these organizations help users identify and articulate demands or stimulate the need for better technology or skills that might enhance the performance of their clients. Moreover, they help users to analyse future needs for technologies and skills, and identify possible sources to meet those growing demands. The accreditation and standards function is also identified for innovation intermediaries, through which they help users to develop standards and set specifications for technical solutions and applications.

Technology brokers, as another type of intermediary, stimulate user demands for existing technologies that might enhance business performance, or for new technologies or applications. For example, in the case of the Kenyan agricultural sector, Kilelu *et al.* (2011) explored the intermediation functions of technology brokers as consultants. The study found technology brokers support users at this stage in an active and pro-active approach. The active approach is when they help users define their problems and analyse future demands through problem solving sessions and strategic planning. In this case, the focus is on analysing the problems and challenges that users face in applying existing knowledge or technologies for production. In contrast, the pro-active role is when brokers stimulate and trigger the demands of users for technologies that are already available but whose uptake with users has been low and that are thought to enhance the user’s performance, or even for technologies or skills that users are not yet aware about. While brokers stimulate the demands of users for external technologies they also stimulate the supply side to respond to the demands of users. They stimulate the suppliers to

generate the technologies or knowledge that might enhance the business of users to ensure the availability of these technologies and inputs.

The functions of intermediaries during this stage implicitly suggest different characteristics of intermediaries in order to get involved in this stage. First, they possess prior knowledge and experience about the technological domain of their operation. Based on prior knowledge, intermediaries are capable of analysing the systems to identify challenges or problems, as well as suggesting external opportunities that might enhance the performance of the system. For instance, Bessant and Rush (1995) noted that consultants are often “retired and experienced industrialists”, which implicitly suggests they possess prior knowledge about the industry or specific technological domain, thus have accumulated industry-specific prior knowledge and experience. This experience enhances the “diagnostic role” of consultants to analyse the existing system and define its problems.

Second, intermediaries involved at this stage are expected to connect to a wider network of users and producers so they can share experiences among different users. For example, consultants and technology brokers were found to connect to various users in the industry or similar industries. This network was reported to enhance their capability to share experiences and problem solving among the different users, in an analogy to bees cross-pollinating between users, carrying experiences and ideas from one location or context into another (*ibid*). Moreover, in order for intermediaries to suggest solutions or sources of solutions for users, it assumes they are connected to networks of suppliers and are aware of the available options (technologies) that might solve the problem or meet the demands. Equally the role of brokers in stimulating the demand and supply side suggest they are strongly connected with both sides, and knowledgeable about them as well.

Additionally, for an intermediary to support in articulating demands of users, it suggests there is a sharing of a common language and understanding about the industry of the problem being analysed. This proximity bridges the communication gap between users and intermediaries. Since consultants were reported to belong

to the same professional field as users, they are able to understand and articulate their needs. Bessant and Rush (1995) highlighted that consultants work closely with their clients so they understand their needs and articulate them. However, what was not explained sufficiently in that study was whether the closeness refers to geographical or cognitive closeness or both.

Likewise, in the context of the Kenyan agricultural sector, Kilelu *et al.* (2011) reported that local consultants (termed as brokers) articulate demands of local users as well as stimulate demands for potential technologies by raising the awareness of users about other possible applications of existing technologies or new technologies. These functions assume a close cognitive proximity between users and brokers so they can understand the demands of each other and can effectively communicate and diffuse external knowledge.

After the internal demands are specified and defined, the next stage is to search the technology market for available options to address the demands.

## **2.9.2 MARKET SCANNING (BUSINESS INTELLIGENCE)**

The second stage for effective technology transfer involves searching for potential technologies/techniques that might respond to the internal demands. This is done through market scanning process (Bessant and Rush, 1995) to select the option that best fits the identified or stimulated demands. This stage involve several tasks such as identifying and assessing options (*ibid*), linking users to networks of suppliers (Clarke and Ramirez, 2013; Li-Ying, 2012), bridging the communication gap between suppliers and recipients (Li-Ying, 2012), performing economic and contractual linkages (Shohet and Prevezer, 1996), and providing financial support (Howells, 2006; Kilelu *et al.*, 2011). The two main factors that influence these functions are networking with producers and information processing – explaining and simplifying (interpreting).

Networking, as highlighted in the previous stage, enhances the capability of intermediaries to identify a range of options from different sources of technologies (Clarke and Ramirez, 2013). Information processing, on the other hand, enhances the capability of intermediaries to simplify and interpret technology related

information for users so the latter are informed about the different options and in a position to select an option (Howells, 2006). Information processing involves simplifying complex and tacit knowledge so it can be understood by recipients to help them assess, select and adopt the best option.

Leonard-Barton (1984) examined the functions of diffusion intermediaries in choosing technologies for less-capable users in the health sector. They were found to select technologies and diffuse them to end-users, influenced by their prior knowledge about both the technologies being transferred and the users' existing systems.

In contrast to intermediary's prior knowledge, users' prior knowledge about technologies also influences the level of knowledge diffused by intermediaries to users. With a knowledgeable user, intermediaries were found to diffuse more information about technologies so users become aware of the different options and can participate in the assessment and selection process of external technologies (Leonard-Barton, 1984). With the less capable users, intermediaries may not diffuse sufficient information or perform the selection function without involving users, so the less capable users remain isolated from the assessment and selection process. However, Leonard-Barton (1984) did not offer adequate explanation about what will be the effect on users learning if diffusion intermediaries did not process (interpret or simplify) information about technologies prior to diffusing them to less-capable users.

Similar to diffusion intermediaries, consultants were also reported to perform market scanning. Bessant and Rush (1995) consider this stage as the second face of consultants' diagnostic functions. Accordingly, consultants identify problems and suggest solutions to address those problems, assessing the various options, prioritizing them and advising on the most appropriate solutions. Howells (2006) called the market scanning stage "scanning and technology intelligence" and suggests it includes information processing as well as gathering and passing information to users.

On their taxonomy of the roles of intermediaries in technology transfers in an emerging agricultural sector, Clarke and Ramirez (2013) called this stage the

"access" role of intermediaries. They suggest it includes exposing users to a wide range of new sources of knowledge, helping to assess the value of different alternatives, or prioritizing options. In their study about the roles of intermediaries in an emerging agricultural sector in the context of Chilli, Clarke and Ramirez (2013) found that producer associations, such as PROMANGO and APEM, played a role of technology intermediary and established themselves as the primary agents for accessing knowledge. They became the focal point through which information by producers and other service organizations was concentrated and then disseminated to local users. Although it is not explicitly said, this role suggests that those intermediaries are capable of absorbing technologies from their sources (external), storing and processing them, and finally diffusing them to different local users.

Due to their strength in networking with various suppliers, technology agents were reported to be more active in linking functions at this stage but less effective in assessing or prioritizing options. Shohet and Prevezer (1996) examined the role of the technology transfer office (TTO) as technology agents within university-industry technology transfer in the UK-biotechnology sector. They found TTO plays a key role in linking producers with users (host universities and potential investors) in terms of economic and contractual linkages. The linkage function includes facilitating negotiation, contractual and deal making, supervising the implementation of the deal between the two parties, ensures potential intellectual property is protected prior to disclosure, and acts as 'auditors' of knowledge within the producer's organisation. However, TTO was found not to perform knowledge linkage between university and industry, which was linked alternatively through the direct producer-users interactions.

In contrast to TTO as technology agents, in cross-national technology transfer systems, technology agents in the form of local manufacturer representatives were reported to perform functions beyond linking and act as interpreters or facilitators between external suppliers and local users. Moreover, they bridge the cultural and language differences between the producers and users of two different transfer systems. For instance, Li-Yin (2012) examined the role of Chinese technology agents with different organizational set-ups (private, public, on-line) within the

Europe-China technology transfer framework. The study found private technology agents enhanced the accessibility of users and producers to each other. Furthermore, due to cultural and language differences between the producer and users, they also facilitated the communication between the producers and users. The study found the role of private agents is enhanced by their prior knowledge about local legal and industrial systems, as well as the share a common language with both producers and users. Although it is not frankly stated, the close proximity (geographic, language and culture) of agents with local users is thought to influence their roles as facilitators and interpreters. Moreover, the organizational set-up (public, private, on-line) might also have an influence on the functions of intermediaries. However, these are not discussed or presented clearly in that study.

As the ultimate goal of the stage is selecting the right option that fits internal demands, information about all options is necessary for users to assess and prioritise options. Information about technologies includes their technical specifications, sources, costs and other necessary information that guides the adoption decision.

The role of intermediaries in market scanning highlights different assumptions about their functions. First, intermediaries are assumed to be aware of the specific contexts for which external technologies are scanned and identified, so the scan process is informed by the context of the internal demands. It is strongly argued that matching the supply and demand sides of technology transfer is crucial for successful transfer process (Andersson, 2009; Ramanathan, 2002). However, as the above review highlighted, not all intermediaries that are involved in market scanning are also involved in demand articulation (for example, the technology transfer office (agents) studied by Shohet and Prevezer (1996)). It is not yet clear what factors induce intermediaries to get involved in either or both stages, and how those factors influence the firm's learning.

Second, scanning the market involves both identifying and assessing various technical options, as well as prioritizing and advising on which ones best suit the needs of users (Clarke and Ramirez, 2013). However, this implies that

intermediaries know about the various options and the context of applications for those options so a match between the two sides can be suggested. This match between demand and supply directly influences the adaptation of technologies and, in turn, learning through combining external with internal technologies (Andersson, 2009; Knockaert and Spithoven, 2012; Nonaka and Krogh, 2009). Consequently, the research on market scanning assumes intermediaries are knowledgeable about the technologies being transferred and the specific contexts where they will be deployed.

Finally, as Howells (2006) and Clarke and Ramirez (2011, 2013) noted, market scanning suggests intermediaries have the capability to process information (that is simplifying, interpreting, articulating, and communicating the information associated with different options, including the cost, specification, operating conditions, etc.). Nonetheless, what makes different intermediaries capable of processing information (or not) remains insufficiently discussed in previous studies. Leonard-Barton (1984) implicitly noted the influences of the characteristics of technologies (tacitness and technical complexity) on intermediaries' ability and willingness to diffuse information, suggesting the more technically complex the technologies are, the less inclined intermediaries are to diffuse them. Likewise, despite not being directly stated, the tacitness of knowledge was reported to hinder the ability of agents to transfer technologies within a university-industry technology transfer setting (Shohet and Prevezer, 1996).

After the internal demands for external technologies are identified and articulated, and the market is scanned to identify the best option, the next stage is to initiate the actual transfer – acquisition.

### **2.9.3 ACQUISITION**

The acquisition of technologies is understood as the actual process of transferring technologies and associated technological knowledge from suppliers to recipients. Bessant and Rush (1995) suggest this stage involves several tasks for intermediaries such as negotiation around price, agreement on specification, transfer of knowledge and property rights as per the agreement. Howells (2006)

added the function of information processing to ensure recipients are able to absorb technologies from external sources, in addition to validation and testing of technologies prior to transfer. Clarke and Ramirez (2011) suggested this stage requires that intermediaries establish infrastructures and relevant spaces for effective diffusion of knowledge. This infrastructure involves qualified personnel, demonstration and testing (validation) workshops, training facilities, and the ability to codify the tacit knowledge associated with technologies, for the ease of the transfer.

As highlighted before, effective transfer for learning is best achieved through the direct producer-user interactions (Cyhn, 2002; Grant, 1996). This is principally to ensure transfer combines both the physical and associated knowledge elements of the technologies being transferred. Effective transfer and learning is supported by the disseminative/tutoring functions of suppliers (Cyhn, 2002). Suppliers simplify and communicate information about technologies to different users and often offer direct interactions (*ibid*).

However, previous studies have found that not all intermediaries are either involved with users at this stage or engage in tutoring (for example, see the study of Seaton and Cordey-Hayes, 1993). For instance, technology transfer agents (TTO) were not found to be involved with users during the actual acquisition, after they linked them with producers and facilitated transfer agreements (Li-Ying, 2012; Shohet and Prevezer, 1996). In contrast, consultants have been reported to be involved with users and to play a policing role during the acquisition, in which they ensure the acquired technologies are consistent with the specifications defined during the demand articulation stage (Bessant and Rush, 1995). Consultants supervise the acquisition process to ensure the rights attached with technologies such as the IP and the agreement terms are all met during the transfer process.

The above functions of intermediaries at this stage of the transfer process suggest different implicit assumptions about intermediaries. First, as learning requires the transfer and absorption of technological knowledge, and that is best achieved through direct interactions, it is implicitly suggested that intermediaries can interact with both users and producers, and being able to communicate in both



directions. This assume intermediaries possess prior knowledge related to the technology (absorptive capacity) in order to absorb it from producers, and that they also possess transfer capacity and infrastructure to communicate technologies effectively to users.

Although intermediaries transfer physical technologies from producers to end-users, their capability in acquiring and transferring the technological knowledge needed for learning, and the factors that influence this role, remain less understood. According to the implicit assumptions in the technological learning theory, in order for intermediaries to substitute for suppliers in disseminating sufficient knowledge, they need both the absorptive capacity and transfer capacity. If intermediaries fail to absorb technologies from producers, they are not expected to diffuse technological knowledge to users, which will negatively influences the user's learning.

Nonetheless, there is a dearth in research that investigates the relationship between the two capacities for intermediaries, and how that influences the user's learning. Moreover, the influences of intermediaries on the effective acquisition and users' learning when they transfer technologies across different transfer systems (e.g. developed-developing countries) with geographical, language, cultural and cognitive proximity are not sufficiently known.

Technological learning highlighted that the acquisition of external technologies is not sufficient for learning if it is not internalized and integrated with the local system (Lin, 2003). Therefore, the acquisition stage is followed by the assimilation stage to ensure learning and absorption of external technologies. This is discussed in the following section.

#### **2.9.4 ASSIMILATION AND LEARNING**

Following the effective acquisition of technologies that includes the transfer of physical technologies and associated technological knowledge, the last two stages of technology transfer are assimilation (internalization) of external technologies and learning – innovation. The significance of these two stages has been

intensively emphasized by technological learning theory and the KBV (see e.g. Kim, 1999; Kumar *et al.*, 1999; Lin, 2003; Nonaka and Krogh, 2009; Viotti, 2002).

Assimilation is the process of integrating and adapting the external technologies with the internal system (Grant, 1996; Zahra and George, 2002). This is done through different activities such as interpreting and simplifying external technologies to a level understood by users (Minbaeva, 2007; Zahra and George, 2002), codifying and communicating tacit knowledge gathered from technological sources (knowledge conversion) (Nonaka and Krogh, 2009), adapting external technologies to local system and make the necessary changes (Ramanathan, 2002), training and demonstration activities (Cyhn, 2002; Kim, 1999), and conducting R&D activities to support the adaptation and long-term learning (Clarke and Ramirez, 2013; Dantas and Bell, 2009; Kim, 1997).

Technology intermediaries behave differently and perform different functions at this stage. Whereas some intermediaries, such as technology agents, have not been reported involved with users in adaptation or learning, others, such as consultants, are reported heavily involved. Prior knowledge of users about technologies being transferred has been reported to play a key function in the role of intermediaries in disseminating external technologies. For instance, Leonard-Barton (1984) reported that diffusion intermediaries transfer physical technologies to less-capable users but they were found to not adequately support the post-transfer stages; to be precise the diffusion of technological knowledge for internalization and long-term learning. For instance, they do not interpret or simplify knowledge; they do not train users into using the transferred technologies, and do not transfer technological knowledge for learning. Intermediaries were found to carry out this stage without involving the end-users. Likewise, technology transfer agents were found not to be involved at these stages (Shohet and Prevezer, 1996). In contrast, consultants are reported to train users in how to use the technologies being transferred (Bessant and Rush, 1995; Kilelu *et al.*, 2011) and help adapt solutions to fit the different users' needs (Bessant and Rush, 1995).

Intermediaries in the form of R&D centres were also found to support assimilation and long-term learning. Szogs (2008) examined R&D centres as intermediaries

operating between external MNEs and local business in Tanzania. The study found that intermediaries translate the knowledge acquired from MNEs into the local language, and help local enterprises to absorb and exploit the potential external technologies. Moreover, they establish infrastructure that encourages interaction among the different enterprises, which develops an interactive learning environment that leads to internalizing external technologies. Clarke and Ramirez (2011) called this role of intermediaries the “coordination and enabling” functions, through which intermediaries establish a basis for cooperation and collaboration to encourage interactions among different isolated users and producers, and to support the adaptation of external technologies and learning. The enabling function involves providing new knowledge inputs and adapting existing knowledge to make it applicable to different contexts and situations.

Intermediaries were also reported to contribute at this stage of the transfer process by adding value to the information acquired from external sources prior to diffusing that to end-users by a combination/recombination process (Howells, 2006). They do that either by combining external knowledge with existing knowledge, or they themselves generate in-house R&D and technical knowledge to combine with the client’s knowledge.

The review of the functions of different intermediaries at this stage implicitly suggests that intermediaries involved with users at this stage possess knowledge about external technologies and firms’ internal systems. This knowledge may enhance their involvement with users and support internalization, learning, and the adaptation of external technologies with the internal system. Likewise, R&D centres that mediate the diffusion of external knowledge to local contexts suggests they are knowledgeable about the knowledge being transferred, and are therefore able to simplify and interpret for local contexts. In addition to being knowledgeable, the involvement of intermediaries with users at this stage also suggests a degree of close cognitive proximity with users, so that they share a common language through which they interpret and simplify external technologies. Furthermore, the combination function of intermediaries through which they generate new knowledge and combine it with external knowledge

suggest that intermediaries are at advance level of technological capability, and they might be a technology producers or partners.

## ***2.10 RESEARCH GAPS***

This chapter reviewed two main bodies of literature, namely technological learning and technology intermediaries. While the literatures provide significant insights for understanding the functions of technology intermediaries during both the technology transfer process and technological learning, the review identified several shortcomings with respect to understanding what functions different types of intermediaries perform, what factors influence those functions and how that influences users' learning. The main gaps that require further research are discussed below.

First, technological learning theory assumes producers transfer technologies to users, thus learning occurs mainly through direct producer-user interactions. Studies on technological learning have identified several functions of suppliers that support users' learning along the transfer process including demonstration, human resource movement and direct interactions. It is still not well understood whether intermediaries can assume the role of direct producers for users when they are the direct suppliers. This is because existing technological learning theory does not explain fully how learning is influenced by the emergence of intermediaries between producers and users. Therefore, this point requires further investigation and is where this study aims to contribute.

Second, technological-learning-theory suggests learning goes through three key stages of acquisition, assimilation and improvement. Despite focusing primarily on firms that initially lack technological capability, the theory does not clearly explain how such firms define their internal demands for external technologies or how they learn about the available options that meet those demands. To be more specific, demand articulation and market scanning have not yet received adequate consideration within technological learning studies, especially in the context of developing countries. Hence, technological learning can be argued to go through five consecutive stages that include the demand articulation and market scanning stages prior to acquisition of external technologies.

Third, the review identified a dearth in research that examined technology intermediaries from the perspective of a technological learning framework in the context of developing countries. Previous studies on technology intermediaries tend to map out and provide a list of different functions performed by intermediaries in a particular context, without clearly stating the theoretical stance they adopt to identify the different functions. Although it is not always articulated, most previous studies on technology intermediaries adopt the linear innovation system framework. This study uses technological learning theory as a theoretical framework for examining functions and factors influencing the functions of intermediaries. It has been highlighted that the innovation system and technological learning frameworks differ from each other in terms of goal, actors and strategies (Kayal, 2008; Viotti, 2002); so functions of the main actors within the system are expected to vary. Whether the functions of intermediaries in the innovation systems framework are equally applicable with the learning framework requires further investigation. The lack of research that examines intermediaries using a learning framework has been recognised by recent studies. For instance, Knockaert and Spithoven (2012) reported that little research has investigated the functions of technology intermediaries in enhancing firms' learning.

In addition, despite intermediaries play key roles in technology transfer and innovation, their roles and functions are less identified in comparison to other actors such as producers, users or investors. Previous studies do not state the role of intermediaries as suppliers or users upon which their functions are identified, thus the factors that influence the functions of intermediaries in different roles are insufficiently explored. Tran *et al.* (2011), for example, argued that existing studies on intermediaries provide rich knowledge about their intermediation functions but do not explain the factors that influence their added value to new product development, nor what capability they need. The study in this thesis examines intermediaries' functions as direct suppliers from a technological-learning perspective, to explore the factors that influence their functions.

Fourth, previous studies on the functions and influences of intermediaries on transfer and learning processes are ambiguous, with studies finding both positive and negative influences. What is not yet sufficiently understood is what factors

make intermediaries influence the process positively or negatively. There is a need for research offering a holistic and thorough examination and analysis of the key factors that influence the functions of intermediaries, which in turn influence the learning process. For example, there is dearth of studies that examine how the characteristics of technologies being transferred, or the capability of users, might influence the functions of intermediaries during the transfer process. Similarly, it is not yet understood how the prior knowledge of intermediaries (specialization) about the technologies being transferred or their proximity to producers and users might influence their functions.

Fifth, with the exception to very few studies that examined technology intermediaries as agents in cross-national technology transfer system (e.g. Li-Ying, 2012), prior research has mainly examined technology intermediaries operating in a single technology transfer or innovation systems with users and producers. Actors within the same system often benefit from several advantages; not the least is the proximity (geographical, language, culture) that enhances the transfer and learning process (Boschma, 2005). For instance, when technology transfer agents perform economic and contractual linkages between producers and users, but not knowledge linkages, the latter was implemented through direct producer-user interactions that were possible due to geographical and cultural closeness (Shohet and Prevezer, 1996). Such interactions were possible because the users and producers were co-located within the same transfer system.

In cross-national technology transfer systems (e.g. developed-developing countries), actors work at a distance (culture, language, geography, knowledge-base) from each other, but the influences of such distance on intermediation functions and on users' learning remains insufficiently understood. There is a lack of research that examines what factors influence technology intermediaries' functions across different transfer systems.

An important gap that has been identified from the literature review is that, despite the growing number of studies on technology intermediaries, limited research has been conducted with regard to developing countries, and Sultanate of Oman in particular. Within the context of technology transfer in developing

countries, the roles and functions of technology intermediaries are even more ambiguous, and studies on technology intermediaries within this context are still limited (Intarakumnerd and Chaoroenporn, 2013). While linkage and networking have been considered as the primary roles of intermediaries (Howells, 2006), their roles for users in developing countries are expected beyond those roles in order to support learning.

As stated earlier, most users of technologies in developing countries suffer less from weak technological capability than from the isolation from technological sources that support their learning (Hobday, 1995; Lall, 1990). This made technology intermediaries, in many cases, act as a direct supplier of technologies for local users. There are several unexplored areas around technology intermediaries, especially in underlying factors influencing their functions. This dearth in research has been highlighted by recent studies that reported most studies on technology intermediaries focus on the experiences of developed countries (Intarakumnerd and Chaoroenporn, 2013; Li-Ying, 2012). To date, few studies have explored this issue within the context of developing countries, and the Sultanate of Oman or surrounding regions in particular.

Moreover, the study of technology intermediaries is contextual (Clarke and Ramirez, 2013). Intermediaries in one context might perform functions that similar intermediaries do not perform in other contexts or with other actors. For instance, consultants within the UK innovation system were reported to perform functions that consultants do not perform within the Kenyan innovation system (see e.g. Bessant and Rush, 1995; Kilelu *et al.*, 2011). That could be largely due to the status of the innovation system of UK compared to the Kenyan system as actors in the UK system might be more developed and established. Thus exploring the functions of intermediaries, and the factors that influence those functions based on the experiences of the Sultanate of Oman will offer a new understanding of the behaviour of technology intermediaries in different contexts than the usual contexts that dominate existing studies.

Thus, this study is a response to the above deficiencies in the literature of technological learning and technology intermediaries. The study, therefore,

represents an early attempt to provide a thorough examination and analysis of how technology is transferred successfully from producers to users through intermediaries in the context of developing countries, and what factors influence the transfer and technological learning process.

### ***2.11 SUMMARY***

This chapter presented the literature review that provided the theoretical foundation for this study. It started by reviewing the main concepts and principles of technological learning theory and how it defines technological learning through the technology transfer process. The initial technological learning framework, which constitutes the three traditional stages of acquisition, assimilation and innovation, was modified into five stages with the addition of demand articulation and market scanning.

The review of technological learning literature identified the main gaps, that hasn't adequately addressed by previous studies, particularly the emergence of technology intermediaries as new actors along the transfer process. The influences of intermediaries remain poorly explained by this theory, not least how and why the new actors might influence technological learning and transfer.

The chapter also critically reviewed literature on technology intermediaries to identify different types of intermediaries and their different functions. This review also highlighted the main gaps in this literature that deserve further investigation; not the least are the factors that influence the functions of intermediaries in the context of developing countries. Moreover, the review also highlighted the lack of research that examines the functions of intermediaries as a direct supplier from the standpoint of technological learning, especially in the context of developing countries.

Based on the intensive review of both literatures, this study suggests that the functions of different intermediaries along the technology transfer process are influenced largely by four interrelated factors. These include the specialization (prior knowledge) of intermediaries, proximity with respect to users or producers (geographical and cognitive), characteristics of technologies (tacitness, complexity,



newness), and the capability of users (absorptive capacity). These concepts will be developed in the conceptual framework that is presented in the following chapter of the research design.

### 3 CONCEPTUAL FRAMEWORK

The central part of this study involves examining how the emergence of technology intermediaries in the international technology transfer process influences the technological learning of users who have weak internal R&D capacities and are geographically isolated from technological sources. The study aims to identify the principle functions of different intermediaries during the transfer process, investigate which factors influence how those functions are performed, and how that influences the recipient's learning.

This chapter presents the conceptual framework that will guide the data collection and analysis of this study, and how it will answer the research questions set out for this study.

#### 3.1 INTRODUCTION

Following the suggestion of Miles and Huberman (1994), and the practice of several researchers on technological learning (e.g. Cyhn, 2002; Easterby-Smith *et al.*, 2008; Kim, 1999; Lall, 1992) and technology intermediaries (e.g. Clarke and Ramirez, 2011; Howells, 2006; Kilelu *et al.*, 2011; Shohet and Prevezer, 1996), a tentative conceptual framework can be developed based on insights from existing theories on technological learning and technology intermediaries. This is complemented by inputs from the pilot study carried out for this research.

According to Eisenhardt (1989), developing a conceptual framework for research prior to data collection can help to shape the initial design of theory-building in case-based research. If the pre-identified constructs (concepts) of the framework prove important as the study progresses, then the study has a firm empirical grounding for the emergent theory (Eisenhardt, 1989). The initial framework is not intended to limit the data collection and analysis process to the main concepts in the framework, but rather to guide it (Miles and Huberman, 1994). As such, the concepts remain tentative at this stage. Miles and Huberman (1994) argued that, without such an initial conceptual framework, a qualitative researcher is in danger of providing descriptions without meanings, or of spending considerable time gathering insignificant information.

In order to achieve the objectives of this study, the two main national firms in the Omani oil and gas industry are judgementally selected. These are Petroleum Development Oman (PDO) and Oman Liquefied Natural Gas (Oman LNG). The two firms are the major players in the Omani economy and in the inward technology transfer system. The functions of intermediaries and the factors influencing those functions are identified and examined from the experiences of these two firms, as expressed by 48 interviewees.

As major technology users, PDO and OLANG rely extensively on external technologies, which are acquired either directly from their producers or via technology intermediaries. The intermediaries and the two firms are located in Oman – both isolated from the technology production market. The main contextual factors of this study are therefore that users rely on external technologies; users acquire external technologies through intermediaries; users and intermediaries are located in a technologically lagging country – isolated from technological sources; and, users and intermediaries possess weak technology production capacity.

### ***3.2 INTERMEDIARIES: DEFINITION, TYPES AND FUNCTIONS***

Intermediaries are examined using a framework drawn from the literature on technological learning and technology intermediaries, as presented and explained in Chapter 2. This involved modifying the technological learning theory to constitute five stages for effective technology transfer, namely demand articulation, market scanning, acquisition, assimilation, and innovation.

While the present technological learning theory helps to understand firms' learning when transferring technologies from external sources, the theory assumes suppliers of technologies are the producers of technologies but does not examine the role of technology intermediaries, and how they influence learning. This gap is the one this study intends to contribute towards addressing.

There is a lack of an established definition for intermediaries (Howells, 2006), let alone definitions of particular types of intermediary such as consultants or agents. This might be due to a lack of theoretical or conceptual groundedness (*ibid*), or the

contextual nature of intermediaries (Clarke and Ramirez, 2011). Accordingly, each study adopts its definition or tends to accept intermediaries as a linkage body between suppliers or users. As such, various terminologies are being used interchangeably to refer to intermediaries (Kilelu *et al.*, 2011); these include consultants, agents, broker, third party.

A recent definition of intermediaries has been introduced in Howells (2006). Howells (2006) examined the functions of innovation intermediaries along the UK-linear innovation system, and defined intermediaries as “an organization or body that acts an agent or broker in any aspect of the innovation process between two or more parties” (p. 720). This definition highlights intermediaries as mainly agents or brokers and suggests all intermediation functions fall within these two types. Despite that, the operationalization of this definition identified other types of intermediaries such as consultants or bridges. Based on an intensive literature review and case studies from the UK innovation system, Howells (2006) proposed a functional-based typology of intermediaries, which, while insightful, does not yet explain clearly how each type of intermediary varies from other types.

Howells's (2006) definition is proposed for intermediaries who operate in an established innovation system such as the UK, where technology is often transferred in forms of technological knowledge (i.e. IP). In contrast, most innovation systems in developing countries are weak and fragmented (Szogs *et al.*, 2011; Viotti, 2002), so one might expect the functions and roles of intermediaries in developing countries to differ from those in developed countries. For example, it has been argued that the aim of technology transfer for firms in developing countries is for learning rather than for innovation *per se* (Bell and Pavitt, 1993; Viotti, 2002). Therefore, this study develops the following definition for intermediaries, which fits the context of developing countries:

*“Organisations or individuals formally engaged in any stage of the technology transfer processes between suppliers and end-users, and possibly providing a variety of intermediation functions to support users along the five stages of technology transfer.”*

The functions of intermediaries in this study are examined along the five stages of the technology transfer process as defined in Bessant and Rush (1995):

1. *Demand articulation/stimulation*: recognition of a firm's requirements for technology or skills;
2. *Market scanning*: exploration and assessment of the range of technological options available;
3. *Acquisition*: acquisition of the technology through the direct purchase or via some other form of acquisition;
4. *Assimilation*: retaining and internalizing technology within the firm; and
5. *Long-term learning – innovation*: extensive learning for innovation.

For an effective technology transfer that might lead to learning, different functions of intermediaries are required along the five stages, as illustrated in Table 3-1. These functions are compiled from different existing studies as follows:

Table 3-1 Technology Transfer Stages and The Intermediation Functions along the Different Stages

TT stages	Definition	Main intermediation functions	References
<b>Demand articulation</b>	The process of recognition and articulation of firm's requirements for external technologies or skills (present and future needs)	<ul style="list-style-type: none"> <li>• System analysis and problem definition</li> <li>• Strategic planning and foresight: future needs analysis for external technologies, skills, and human resources</li> <li>• Demands articulation/stimulation or opportunity identification</li> <li>• Specifications and standards development</li> <li>• Sharing experiences and problem solving from different users</li> </ul>	Bessant and Rush, 1995; Howells, 2006; Kilelu <i>et al.</i> , 2011
<b>Market scanning</b>	Exploration and assessment of a range of various technological options	<ul style="list-style-type: none"> <li>• Identify technologies and sources</li> <li>• Information processing and diffusion for adoption decision</li> <li>• Access, assess and select the best option as per user context and needs</li> <li>• Contractual and financial linkages</li> <li>• Provide financing and funding, legal advices</li> <li>• Linking users with networks of suppliers</li> </ul>	Bessant and Rush, 1995; Clarke and Ramirez, 2011; Howells, 2006; Kilelu <i>et al.</i> , 2011; Leonard-Barton, 1984; Li-1993; Shohet and Prevezer, 1996
<b>Acquisition</b>	Acquiring (import) technologies through direct purchase or via some other forms of acquisition	<ul style="list-style-type: none"> <li>• Supervise the deal implementation (specifications, IP rights, services and maintenance...)</li> <li>• Knowledge processing: Simplify and interpret</li> <li>• Linking users with suppliers and encourage interactions</li> <li>• Enhance/facilitate user-supplier interactions</li> <li>• Carry-out the logistical tasks for the transfer process</li> <li>• Provide the space for training and hands-on learning: Demonstration</li> </ul>	Bessant and Rush, 1995; Clarke and Ramirez, 2011; Howells, 2006; Kilelu <i>et al.</i> , 2011; Li-Ying, 2012; Shohet and Prevezer, 1996; Szogs <i>et al.</i> , 2011
<b>Assimilation</b>	Retaining and internalizing external technologies within the firm	<ul style="list-style-type: none"> <li>• Knowledge processing</li> <li>• Adaptation and configuration</li> <li>• Codification of external technological knowledge</li> <li>• Demonstrate the different uses of technologies</li> <li>• Knowledge about the external and internal technological domain</li> <li>• Combination of external and internal knowledge</li> </ul>	Bessant and Rush, 1995; Clarke and Ramirez, 2011; Howells, 2006

<b>Innovation</b>	Extensive and planned learning for innovation	<ul style="list-style-type: none"> <li>• Provide environment/platforms for interactive learning</li> <li>• R&amp;D facilitates – new knowledge generation</li> <li>• Adapt existing knowledge to different/specific context: customization</li> <li>• Combining existing technologies in new ways or for different applications</li> <li>• Link users together and with R&amp;D centres</li> </ul>	Bessant and Rush, 1995; Clarke and Ramirez, 2011; Howells, 2006; Kilelu <i>et al.</i> , 2011; Szogs <i>et al.</i> , 2011
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*Source: table developed by the author*

Given our assertion that these functions are all critical for intermediaries operating in developing countries, the literature review noted that not all intermediaries are involved along the five stages nor do they perform all the functions, even in the developed countries (e.g. Howells, 2006; Li-Ying, 2012; Shohet and Prevezer, 1996). Moreover, not all intermediaries diffuse sufficient information about technologies (Leonard-Barton, 1984), and not all are involved in the post-transfer stages (Seaton and Cordey-Hayes, 1993). However, it remains unclear what factors make an intermediary perform a particular function and how that influences users' learning.

### **3.3 FACTORS INFLUENCING THE FUNCTIONS OF INTERMEDIARIES**

Building on the literature review, this study suggests that functions of intermediaries (along the five stages of technology transfer) are influenced by four interrelated factors that, in turn, influence the effectiveness of technology transfer and firms' technological learning. These factors are the proximity of intermediaries with respect to users or producers, the technical specialization of intermediaries, the characteristics of the technology being transferred, and the capability of users of technologies. As the literature review highlighted, there are strong theoretical and conceptual bases to suggest these factors influence the functions of intermediaries during the transfer process. The following sections develop these factors and explain how they might influence the transfer and firms' learning process through intermediaries.

### 3.3.1 THE INFLUENCE OF PROXIMITY

Proximity in this study includes both geographical and cognitive dimensions between intermediaries and end-users. Geographical proximity refers to the spatial distance between them (Rebolledo and Nollet, 2011); while cognitive proximity refers to the degree to which they share similar experience, knowledge base, understanding, language and culture (Boschma, 2005).

Ample research has been conducted on the influences of proximity on technology transfer and learning (e.g., Arundel and Geuna, 2001; Bönnte, 2008; Boschma, 2005; Nooteboom, 2000). For instance, cluster theory found that knowledge is faster transferred between organizations located in a close proximity (Ganesan *et al.*, 2005). This suggests that knowledge transfer is geographically concentrated. Likewise, the innovation literature argues that countries that managed to catch up have often been in close geographical proximity to countries with a developed innovation system (Freeman, 1994).

For instance, by using econometric data of firms located in the UK, Griffith *et al.* (2009) found the geographic proximity to frontier firms hastens the process of other firms' learning and catching-up. Likewise, Kalvet and Kattel (2006) found that European countries have benefited at their early stage of industrial development from a close geographical proximity with the UK, which possesses a developed innovation system. Historically the United States has benefited from a close cultural similarity with UK, and more recently Eastern Europe has benefited from a close cultural and geographical proximity to Germany (*ibid*).

In the 1980s and 1990s, Hobday (1995) argued that China profited substantially in its learning and catch-up from cognitive proximity (linguistic, cultural and close family ties) to Hong Kong and Taiwan (Hobday, 1995). Likewise, the "absorptive capacity" of a firm (Cohen and Levinthal, 1990), and the technology trajectories (Dosi, 1982) that are followed, depend on knowledge transfer and technological collaboration among actors with cognitive proximity (similar technology/knowledge bases) (Woerter, 2012).



Different studies define and examine different dimensions of proximity such as geographical, cultural, language, or capability (knowledge base). Accordingly, results achieved on the influences of proximity on inter-firm technology transfer and learning lack consistency. According to Boschma (2005), understanding the influences of proximity on technology transfer is crucial to understanding interactive learning and innovation. In order to gain a thorough understanding on the influences of proximity on knowledge transfer, Boschma (2005) argued that the different dimensions of proximity, including geographical and cognitive, are examined together.

Technological learning theory argues that tacit technologies are the essence of learning, and effective transfer and absorption of such knowledge requires direct interaction with its source (Grant, 1996; Lall, 1992). As the interactions happens at the level of individuals, direct interaction is argued to best occur within a close geographical and cognitive proximity that allows direct face-to-face communications between sources and recipients of technologies (Cyhn, 2002; Leonard-Barton and Sinha, 1993; Szogs *et al.*, 2011). Knockaert and Spithoven (2012) claimed that the amount of face-to-face contacts benefits from geographical proximity between people or organizations, positively influencing the exchange of knowledge. Likewise, Boschma (2005) highlighted that geographical proximity brings people together, favours information contacts and enhances the exchange of tacit knowledge. However, Boschma (2005) also highlighted that, although interactive learning requires the interactions at the individual level of source and recipients, physical closeness is not a condition. Boschma (2005) further argued that the possibility of overcoming physical distance by modern information and communication technologies (ICT), allows direct interactions at a larger distance.

Similar to geographical proximity, cognitive proximity is highly emphasized for technology transfer within inter-firm technology transfer. Studies on technological learning emphasize the process of bridging the cognitive gaps between sources and recipients through developing the recipient's absorptive capacity with the supplier's transfer capacity (Cohen and Levinthal, 1990; Kim, 1999; Mu *et al.*, 2010). This is obvious in the work of Boschma (2005) when said, "the capacity of

actors or firms to absorb new knowledge requires cognitive proximity", referring to the closeness between the capacities/capability of supplier and that of recipient.

Boschma (2005) and Woerter (2012) argued that firms of similar knowledge base and expertise are in a cognitive proximity and learn faster from each other than among firms with a different knowledge background. In contrast, the gap in technological capability between suppliers and recipients has been highlighted as a key reason for the failure of inter and intra firm technology transfer and learning (Mu *et al.*, 2010; Nakandala *et al.*, 2012).

For instance, Kim (1999) highlighted that the lack of absorptive capacity with the recipient's firm (capability gap) is the reason for the failure of learning with most firms in developing countries as they transfer technologies from technologically advanced suppliers from the developed countries. Likewise, Szulanski (1996) highlighted that intra-firm knowledge transfer is influenced by the cognitive closeness between source and recipient. Within the intra-firm knowledge transfer, Nooteboom (2000) argued "organizations need to be able to reduce cognitive distance between its members, i.e. to achieve a sufficient alignment of mental capability, to understand each other and achieve a common goal" (Nooteboom, 2000, p. 71). However, while Nooteboom (2000) emphasised the cognitive proximity for knowledge transfer, also highlighted the positive effect of the cognitive gap among individuals within firms as it had the merit of novelty – bringing new input. The same notion was emphasized in Boschma (2005) as too close proximity hinders the transfer of new input from external source, due to lock-in effect on individuals within the firm.

However, previous results on the influences of proximity were mainly achieved within the direct producer-user technology transfer, yet the results so far are not conclusive. For instance, while lack of proximity (geographical and cultural) between source and recipient was reported to hinder inter-firm technology transfer and learning in the context of strategic alliances (Nooteboom, 2000; Simonin, 1999), it was found not to have a significant impact on the learning within the buyer-supplier interaction along the same innovation system of strategic alliances (Rebolledo and Nollet, 2011). Similar to Boschma (2005),

Rebolledo and Nollet (2011) argued that modern communication media such as e-mails substitute for geographical distance, thus geographical distance doesn't negatively influence technology transfer. On the other hand, Knockaert and Spithoven (2012) found a geographical proximity influences the intensity of direct user-supplier interactions, which in turn influence the knowledge transfer. However, almost all previous studies on technology transfer agree on the influences of the cognitive proximity - when it is perceived in terms of suppliers transfer capacity and user's absorptive capacity - on the transfer and learning process (Boschma, 2005; Kim, 2001; Mu *et al.*, 2010; Szulanski, 1996).

Nonetheless, within the intermediary-user technology transfer, the influences of the proximity on the technology transfer and users' learning are not adequately understood. Both geographical and cognitive dimensions of the proximity are expected to influence the functions of intermediaries. Technology transfer through intermediaries might go through multiple actors, who might belong to different locations, knowledge, capability, culture, understanding on the technologies or industry, and with different language. The effects of these dimensions of proximity on functions of intermediaries have not received sufficient investigation.

Intermediary-user proximity is believed to enhance the direct interactions, boost the capability of intermediaries to learn about the specific demands of the users, understand and articulate their demands, and absorb their organizational language and culture. For instance, sharing a common language is thought to enhance the capability of intermediaries to simplify external technologies to a level understood by users through using organizational language (Bessant and Rush, 1995; Welch and Welch, 2008). In addition, an intermediary with a proximity with users is expected to gain user-specific knowledge, which is an essential element to support users in analysing the system problem, suggest solutions, and adapt external technologies to fit the internal system (Bessant and Rush, 1995; Howells, 2006).

Therefore it is possible to argue that understanding the effect of proximity on functions of intermediaries still requires further investigation.

### 3.3.2 THE INFLUENCE OF SPECIALIZATION

Specialization of intermediaries can be understood as the domains of technology an intermediary specializes to transfer, and/or sectors that an intermediary specializes to serve (Bessant and Rush, 1995; Howells, 2006). Similar to proximity, there is dearth of research that has examined the influences of specialization on the functions of intermediaries.

Specialization is expected to influence the intermediation functions in two main possible ways. First, specialization increases the endowment of prior knowledge of intermediaries about the industry and its technological domain. This is expected to enhance their ability to understand the industry or the technological domain of their speciality, analyse its problems, suggest solutions, and enhance the user's learning. As Howells (2006) noted, specialized intermediaries in certain industries or technological domains are expected to have more complete knowledge about the various technologies in those domains. That is because different sectors operate under different technological regimes (Dosi, 1982; Pavitt, 1984), thus each sector needs to have intermediaries who understand it and are dedicated to its advancement (Intarakumnerd and Chaoroenporn, 2013). For instance, technological domain and knowledge base in biotechnology industry is expected to differ from that of the oil and gas industry. Therefore, an intermediary who operates and performs in one domain will not necessarily perform in the other.

Second, specialization influences intermediation functions through the acceptance of users to intermediaries' support at different stages of the transfer process. Users tend to accept at face value the judgement and advice of suppliers when they are perceived knowledgeable and reliable (Bessant and Rush, 1995; Szulanski, 1996).

Moreover, as specialization enhances the endowment of knowledge about the industries or technological domain in which intermediaries operate, it is also expected to influence the learning capability of intermediaries about that domain and industries. This is in line with the "path dependency" argument of technological learning, as present learning is influenced by the prior related knowledge (Cohen and Levinthal, 1990; Kim, 1999). Moreover, an intermediary who is knowledgeable about the technologies being transferred is expected to be

more capable of simplifying and diffusing that technology to support the user's absorption, adaptation and learning. Likewise, a specialized intermediary in a particular industry is expected to be in a better position of understanding and identifying the challenges that might face that industry, and accordingly contribute to addressing those challenges.

On the other hand, a lack of specialization might hinder the capability of intermediaries to learn about various technologies, since different technologies require different learning capabilities (Steensma, 1996). The lack of specialization moderates the prior related knowledge of intermediaries about the technological domain or the industry, which, according to technological learning theory, negatively influences their learning capability.

Within technology intermediary studies, terms such as "expertise" or "prior knowledge" have been used indirectly to denote the specialization of an intermediary. For instance, Leonard-Barton (1984) highlighted that the "particular expertise" of a diffusion intermediary influences their capability to choose technologies for less capable users. The selection process of technologies for less-capable users involves different functions thus it is possible to suggest that without the particular expertise, diffusion intermediaries will not be able to perform those functions associated with selection.

Similarly, Bessant and Rush (1995) noted that consultants are often retired industrialists with "accumulated knowledge and experience", implicitly suggesting that consultants have a specialization in the industry they serve, which in turn has enhanced their consultancy functions during the transfer process. Howells (2006) also noted that the field-specialization of intermediaries enhances their capability in simplifying complex technologies and facilitating users' learning.

Previous studies on inter-firm technology transfer have rarely discussed the influence of specialization (prior knowledge) on the functions of suppliers along the transfer process. That might be due to the implicit, and widely adopted assumption, that the supplier is the original producer who is assumed knowledgeable about the technology being transferred. Most discussion about the influences of suppliers on the transfer process has addressed their

transfer/disseminative capacity in terms of the ability and willingness to articulate and communicate knowledge to users (Minbaeva, 2007; Mu *et al.*, 2010; Szulanski, 1996).

When a supplier is an intermediary, it cannot be assumed knowledgeable about the technology being transferred. Instead, they start with zero prior knowledge and accumulate as they specialise in a particular domain or an industry. Hence, their prior knowledge is likely to have a significant influence on their functions during the transfer process. Therefore, the transfer capacity of an intermediary is not only a function of their communication capability but also of their prior knowledge (specialization) about the technology being transferred, as they are expected to transfer technologies that they possess prior knowledge about it.

Based on the above discussions, this study will explore the influences of proximity and specialization on the functions of two main types of intermediaries – consultant and technology agents (producer representative). The pilot study of this research identified that these two types of intermediaries dominate the technology transfer system in the local oil and gas industry in Oman (and elsewhere). The combinations of proximity and specialization are expected to develop intermediaries with certain skills and capabilities who might perform different functions along the stages of the transfer process. For instance, when the function of intermediaries is to support the adaptation of new technology into internal systems, an intermediary who is close to users and specializes in the domain or industry is expected to perform better. An intermediary with a proximity to users is expected to develop a user-specific knowledge and be able to identify and articulate their demands.

However, if that intermediary does not specialize in the industry or the technological domain of users, the lack of prior knowledge about the industry might hinder the ability to analyse the system, assess different technologies, simplify or interpret knowledge. Moreover, an intermediary with a close proximity to users, and who specializes only in the technological domain of a user's industry, might be able to support a user's absorption and adaptation of a similar technological domain but might not be able to support new or complex technologies

or technologies from outside the domain. This is due to the lock-in effect that is generated by too close proximity (Boschma, 2005).

For this study, the following guiding definitions for consultants and agents are developed and adopted:

- Consultants are often experienced personnel in their clients' industry and work in proximity to their clients. They can be specialized in a specific technological domain or industry or non-specialized and offer general consultancy. They can be a single operative (one-man), or form a small-to-large organization. They might be involved with users along the full technology transfer process (general consultancy), or provide specific services at particular stages (special consultancy) (Bessant and Rush, 1995; Howells, 2006; Kilelu *et al.*, 2011).
- Agents (producer representative) are more often in proximity to producers rather than users. They can specialize in supplying a certain domain of technologies or serving particular industries, and can also be non-specialist and supply a range of technologies across different industries (Howells, 2006; Li-Ying, 2012; Shohet and Prevezer, 1996).

### **3.3.3 THE INFLUENCES OF TECHNOLOGY CHARACTERISTICS (TACIT, COMPLEX, NEWNESS)**

Previous studies have recognized the influences of the characteristics of technologies being transferred on the suppliers' capability to transfer, and users' ability to learn (Lin, 2003; Nonaka and Krogh, 2009; Simonin, 1999; Steensma, 1996). The main characteristics of technologies influencing the transfer and learning process are the "tacitness" (Li, 2012; Szulanski, 1996; Zander and Kogut, 1995), "technical complexity" (Lin, 2003; Simonin, 1999), and "novelty" or newness (Steensma, 1996; Zander and Kogut, 1995). These characteristics influence the transfer process by influencing the capability of suppliers to articulate, simplify and communicate technologies (Cyhn, 2002; Easterby-Smith *et al.*, 2008; Minbaeva, 2007), and the capability of users to absorb and internalize (Cohen and Levinthal, 1990; Lall, 1992).

Szulanski (1996) used the term “stickiness” to describe the difficulties encountered in transferring tacit knowledge. Due to its sticky nature, the transfer of tacit technologies often requires direct supplier-user interactions (Cyhn, 2002; Grant, 1996; Lall, 1992), the use of a common language (proximity) (Kogut and Zander, 1992), tutoring activities from its source (Cyhn, 2002), the ability to communicate (simplify and interpret) knowledge at a level understood by users (Minbaeva and Michailova, 2004; Mu *et al.*, 2010), and a high level of absorptive capacity from recipients (Cohen and Levinthal, 1990; Kim, 1999).

Technical complexity of technologies refers to “the number of interdependent technologies, routines, individuals, and resources linked to a particular knowledge” (Simonin, 1999, p. 600). It is argued that the difficulty of technology transfer and learning increases with increases in the complexity of the technologies being transferred (Kogut and Zander, 1992). Technical complexity of technologies develops as a result of the several contents of a technology. For instance, growing technology convergence (i.e. the merging of different technologies in a single technology) has increased the technological contents of technologies, which has led to higher numbers of knowledge components from different areas being incorporated into a single technology (Grindley and Teece, 1997). This made technologies more sophisticated and complex. Accordingly, transferring complex technologies requires different skills and competencies from the source and recipients of technologies. Minbaeva (2007) highlighted that the inter-firm technology transfer of complex technologies is difficult as it draws upon multiple kinds of interrelated competencies (see also Steensma, 1996).

Novelty or newness of technology refers to “the contrast between the incoming technology and that already exists within the recipient firm” (Steensma, 1996, p. 4). It has been noted that new technologies that differ from the existing technologies can make the current skills obsolete (Steensma, 1996), and hence transfer and learning can become slow and expensive. According to Schulz (2001), the transfer of new technologies often requires intensive activities associated with adaptation to the new context. “A new technology developed in one location might (or might not) require changes in business practices elsewhere” (Schulz, 2001, p. 664). The novelty of technology is mainly assessed by the degree of the



relationship and similarity between the transferred and the existing technologies with users (Simonin, 1999), or the amount of change in the internal system it incurs (Schulz, 2001), or the amount of customized absorptive or transfer capacity it requires (Cohen and Levinthal, 1990; Mu et al., 2010).

The newness of technologies is expected to introduce significant influences on the transfer process within the oil and gas sector. Due to the differences in the underground operating conditions from one site or field to another, a technology that might perform in one site does not necessarily mean it will perform in another site. Therefore, the transfer of new technologies might require changes, not only in the skills and capability of intermediaries and that of recipients, but also in the existing system to get adapted to the new technology.

While the influences of technologies on the supplier's transfer capacity have been intensively examined in previous studies, it did not receive adequate attention when suppliers are intermediaries. With the exception of the few studies, such as Leonard-Barton (1984) and Shohet and Prevezer (1996) that did not even explicitly discuss the influences of technologies on the functions of intermediaries, there is dearth of research examining how technologies influence intermediaries' functions, or how they, in turn, influence users' learning.

Based on the above discussion, the characteristics of technology being transferred are expected to influence the capability and functions of intermediaries along the transfer process, as shown in Table 3-2. This table has been developed based on the following assumptions that are compiled from both literatures:

- Analysing or diagnosing complex or novel technological systems requires multi-dimensional knowledge about the technology and the receiving system (Bessant and Rush, 1995; Steensma, 1996).
- Acquiring and diffusing tacit knowledge requires interactions with high level of absorptive and transfer capacity (Mu *et al.*, 2010; Szulanski, 1996).
- The transfer of new and novel technologies requires knowledge about the novel features of technologies (Grant, 1996; Schulz, 2001; Steensma, 1996), and knowledge about the receiving system

- Processing tacit knowledge involves interpreting and simplifying that knowledge to a level understood by recipients (Howells, 2006; Mu *et al.*, 2010).
- Adapting and customizing or modifying technologies for specific applications requires the knowledge about external technologies and internal system capability.

**Table 3-2 The Influences of Characteristics of Technologies on the Capabilities of Intermediaries and their Functions along Transfer Process**

Technology	Novelty	
	High (new to existing)	Low (similar to existing)
<b>Tacit and complex</b>	<ul style="list-style-type: none"> <li>• Close to technology market to understand the novel features</li> <li>• Close to user market to support the use, adaptation and exploitation</li> <li>• Specialization in the technologies/ system</li> <li>• Demonstration and interaction facilities</li> </ul>	<ul style="list-style-type: none"> <li>• Close to user market to support the use, adaptation and exploitation</li> <li>• Specialization in the technologies/ system</li> <li>• Demonstration and interaction facilities</li> </ul>
<b>Codified and simple</b>	<ul style="list-style-type: none"> <li>• Close to technology market to understand the novel features</li> <li>• Specialization in the technologies/system (locked-in)</li> <li>• Demonstration and interaction facilities</li> </ul>	<ul style="list-style-type: none"> <li>• Certain level of absorptive and disseminative capacity from users and suppliers</li> </ul>

*Source:* The table is developed by the author

It is expected that the characteristics of intermediaries in terms of proximity and specialization determine their capability to transfer technologies of different characteristics (tacit, complex, novelty) and support users' learning. For instance the transfer of new technologies requires an intermediary who specializes in the technology and is knowledgeable about its novel features in addition to being in a proximity to users to support the absorption and adaptation of the new technology. Likewise, the transfer of a complex technology similar to an existing requires an intermediary who is in a proximity to users and knowledgeable about the different elements of technologies.

### 3.3.4 THE INFLUENCES OF USERS OF TECHNOLOGIES (ABSORPTIVE CAPACITY)

It has been established that the absorptive capacity of users, as recipients of external technologies, is the main factor influencing the transfer and learning process from external sources (Cohen and Levinthal, 1990). However, previous studies have mainly focused on examining the influence of capability of users on their internal learning rather than on how it might influence the functions of suppliers along the transfer process. This study combines both influences as explained in the following section.

In their influential and highly-cited work, Cohen and Levinthal (1990) defined absorptive capacity as the “firm’s ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends” (Cohen and Levinthal, 1990, p. 128). Absorptive capacity dominates the discussion of technological learning and became one of the most cited learning capabilities (Lane *et al.*, 2006; Noblet *et al.*, 2011). It was argued that absorptive capacity determines the level of learning from external sources, and the ability to internalise that knowledge (Cohen and Levinthal, 1990; Kim, 1999). On the other hand, the lack of recipient’s absorptive capacity hinders both the intra- and inter-firm technology transfer and learning (Cohen and Levinthal, 1990; Kim, 1999; Kumar *et al.*, 1999; Lane and Lubatkin, 1998).

Absorptive capacity is a function of prior related knowledge and the intensity of efforts (Cohen and Levinthal, 1990). Prior knowledge determines the level of learning from external sources in a path dependent fashion, as firms learn in areas closely related to their existing practices (Kogut and Zander, 1992). Mowery *et al.* (1996) argued that, prior related knowledge “endowment of relevant technology” determines the level of inter-firm learning within a strategic alliance as it bridges the cognitive gap between the allied partners. The path dependency argument implicitly highlights the influences of specialization on learning. It basically suggests that a user who specializes in certain technological domains learns faster about similar domains or related fields than about a technology from outside the domain. In addition to its influences on driving internal learning, absorptive capacity has also been identified to bridge the technological gap (cognitive)

between suppliers and recipients (Nooteboom, 2000), as it enhances the level of user's interactions with suppliers (Cyhn, 2002).

However, the influences of user's absorptive capacity on supplier's functions have not received adequate recognitions. Apart from a few number of studies, such as Dantas and Bell (2011), and Lim (2005), there is almost no discussion of this issue. For instance, suppliers were reported to be more motivated to engage in technology transfer with capable users (Lim, 2005). Likewise, in the case of catching-up with firms in the oil industry, Dantas and Bell (2011) found the recipient's absorptive capacity (technological capability) acts as an incentive for suppliers to engage in interactive learning and accept recipients in their knowledge network.

Nonetheless, there is dearth in research that examined the influences of recipient's absorptive capacity on the behaviour of intermediaries along the transfer process. With an exception of the study of Leonard-Barton (1984) that implicitly pointed to the influence of the user's prior related knowledge on motivating diffusion intermediaries to diffuse more information, there are almost no other studies that investigated the influences of this factor on intermediaries.

Leonard-Barton (1984) noted prior knowledge of users about the technology being diffused makes intermediaries motivated to diffuse more information about technologies, making users better informed and able to participate in the transfer process from the assessment and selection to the adoption. In contrast, when the user lacks prior knowledge, the study found intermediaries screen the level information about technologies being transferred and insufficient information is diffused to users. The lack of prior knowledge makes users less involved in the transfer process and makes intermediaries perform all functions of the transfer from assessment through to adoption decision without the involvement of users. Less capable users were found to suffer the consequences of insufficient information about the technologies, which negatively influences the adaptation and long-term learning. Therefore, in response to the dearth of research, this study will explore the influences of users' internal absorptive capacity on the functions of intermediaries along the transfer process, and eventually on internal learning.

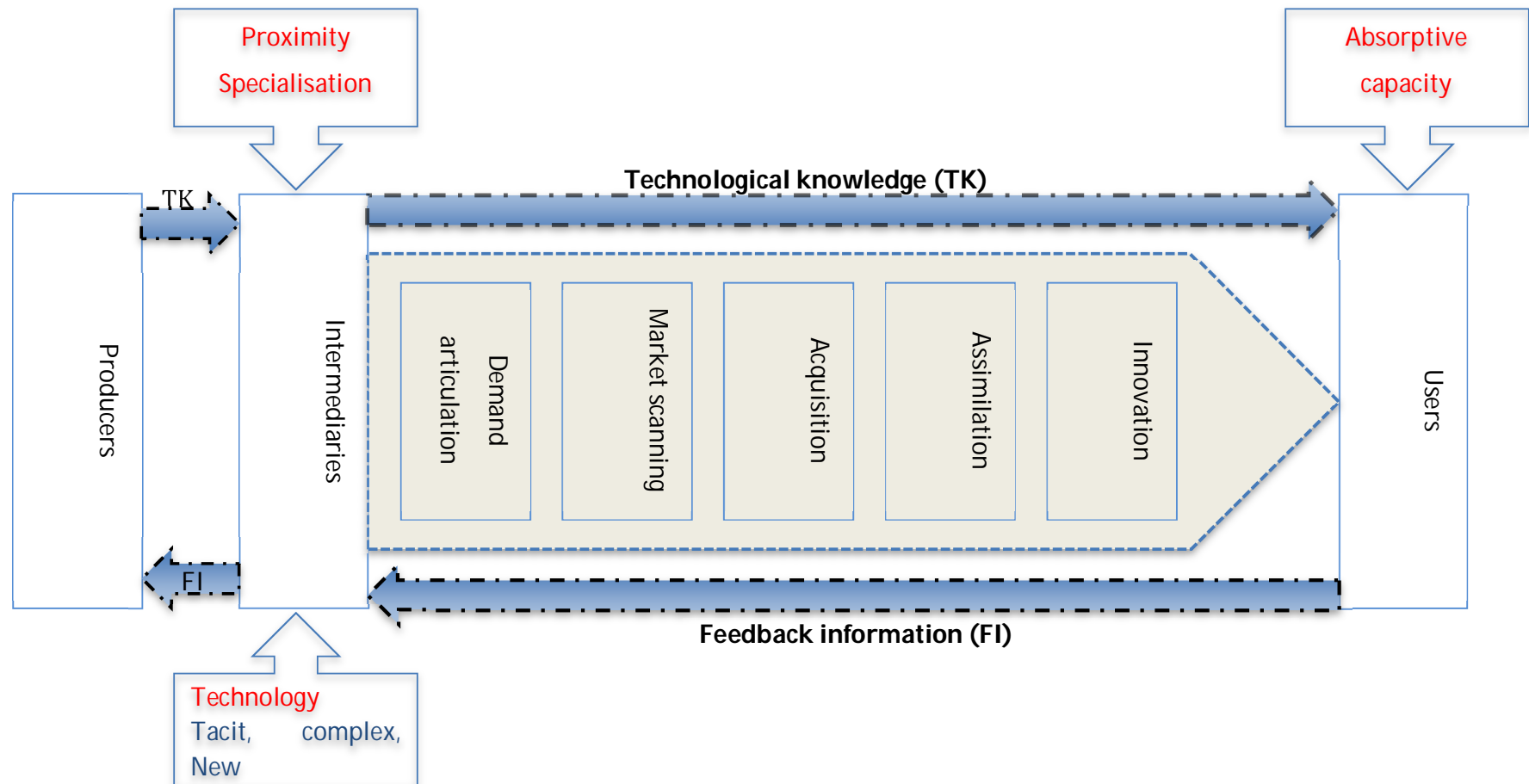
Based on the above discussion and explanation of the proposed four influential factors, a graphical conceptual framework of the proposed tentative factors has been developed, as can be seen in Figure 3-1 below.

### ***3.4 SUMMARY***

This chapter developed a tentative conceptual framework of factors that it is suggested to influence the functions of intermediaries during the process of technology transfer. These factors are the proximity, specialization, characteristics of technology being transferred, and the capability of users (absorptive capacity). These were derived from insights provided by technological learning theory and technology intermediaries. The chapter also explained why these factors are thought to influence intermediaries' functions.

Having developed and presented the conceptual framework, the next chapter presents the research methodology to implement this research.

Figure 3-1 The Proposed Influential Factors on Technological Learning through Intermediaries: a Tentative Conceptual Framework



## **4 RESEARCH METHOD**

### ***4.1 INTRODUCTION***

This chapter explains and justifies the research method for this study. The study adopted a qualitative multiple case-based approach that employed semi-structured interviews for data collection. Qualitative content analysis was then employed for the data analysis. The multiple cases were chosen “judgementally” (Berg, 2001, p. 32). The following sections explain the details of the research design. The chapter explains the underlying philosophical perspective of the study that is used to ensure research rigour and the quality of the study and its results. In addition to this introduction, this chapter involves ten sections and a summary.

### ***4.2 RESEARCH PARADIGM***

Saunders *et al.* (2007) define the research paradigm as “a way of examining social phenomenon from which a particular understanding of the phenomenon can be gained and explanation attempted” (p. 112). There are three paradigms that guide field research in the social sciences: positivism, critical realism and interpretivism (Willis, 2007). These are based on three different philosophical approaches to ontology, epistemology and methodology (Guba and Lincoln, 1994), for generating acceptable knowledge (Saunders *et al.*, 2007), as illustrated in Table 4-1.

**Table 4-1: Research Paradigms and Research Philosophy: Relationships**

Research paradigm	Research philosophy		
	Ontology (Nature of reality)	Epistemology (Researcher-reality relationship)	Methodology (Finding out about reality)
Positivism	Single objective reality exists	Reality exists independent of researcher (objective)	Survey, simulation, experiment
Critical Realism	Virtual or historical reality, sensation	Researcher-reality are interactively linked (Subjective)	Case study, grounded theory
Interpretivism	Multiple and socially constructed realities	Reality and researcher are coupled (Subjective)	Case study, ethnography, action research

*Source:* Compiled from Creswell, 2002; Denzin and Lincoln, 2005; Guba and Lincoln, 1994; Saunders *et al.*, 2007

This study adopts the interpretivism paradigm. While it is beyond the scope of this study to give a detailed account of the philosophical debates related to epistemology, ontology or methodology, nonetheless, the reasons for adopting an interpretive approach are discussed below.

#### **4.2.1 INTERPRETIVISM**

The interpretivism paradigm is mainly concerned with understanding how humans make sense of the world (Saunders *et al.*, 2007) based on a view of reality that is at least partially social constructed (Creswell, 2007). According to Saunders *et al.* (2007), the interpretive paradigm is often particularly appropriate for research in the management and business fields, the field of this study. This paradigm focuses on how people make and interpret the world around them through sharing their experiences via the medium of language (Easterby-Smith *et al.*, 2002). To an interpretivist, knowledge is not only about facts or objects, but also includes emotions and how things are given meaning by people (Easterby-Smith *et al.*, 2002; Saunders *et al.*, 2007). Because it does not adopt a positivist separation of observation from reality, researchers adopting this paradigm sometimes become part of the phenomena that is being researched (Easterby-Smith *et al.*, 2002).



The interpretive paradigm stresses human interpretation and understanding (Saunders *et al.*, 2007). Accordingly, knowledge is often created through the interpretation, or the view, of researchers about the phenomenon as it is seen from the viewpoint of participants (Creswell, 2007; Kim, 2003; Saunders *et al.*, 2007). So **rather than aiming to prove or otherwise a hypothesis, as in the positivist paradigm, interpretive approaches try to identify, explore and explain how the factors in a particular setting are related and inter-dependent** (Oates, 2006). Accordingly, the aim of this paradigm is not to achieve statistical generalization but rather analytical, judgemental or relevance generalization (Miles and Huberman, 1994; Yin, 2014). This refers to the extent to which the findings from the study can be used as a guide to what might occur in other cases with similar situations or contexts (Kvale, 1996). Generalization from this paradigm is based on the representation of the case to a large population (Morgan, 2012). Instead of demonstrating causality among the different constructs as in positivism philosophy, the interpretive approach aims to increase overall understanding of the phenomenon being researched (Easterby-Smith *et al.*, 2002).

**An interpretive paradigm was adopted for this study due to several reasons.**

First, this study attempts to address a gap in the existing theories that do not sufficiently explain technological learning through intermediaries for firms with weak R&D capacities that are isolated from technological sources. Where insufficient research has been conducted on the topic, exploratory research within an interpretive paradigm is arguably the most appropriate approach (Miles and Huberman, 1994), as it generates new insights into the phenomenon under its natural context.

Second, this study aims to learn about factors that influence the intermediaries' functions along the technology transfer process, which, again, remains under-explored in previous studies. An interpretive approach allows identifying and exploring areas where there is limited understanding, by interpreting the meaning gained from the participants in their natural context (Easterby-Smith *et al.*, 2002). Technology transfer and technological learning through intermediaries is under-researched in the context of developing countries, and what is known mainly relates to the different functions that intermediaries have at different stages of the

transfer process. Previous studies have treated these functions in isolation, and their influences on the overall transfer and learning process remains poorly investigated. Understanding these functions and the factors influencing them within a learning framework potentially provides new understanding. Since this is exploratory in nature, an interpretive approach is the most suitable (Rowlands, 2005).

#### **4.3 RESEARCH PURPOSE**

Research typically has three main purposes – explanatory, exploratory and descriptive (Saunders *et al.*, 2007). This study emphasizes exploration purpose. Exploratory research is defined as “research that aims to seek new insights into phenomenon, to ask questions, and to assess the phenomenon in a new light” (Saunders *et al.*, 2007, p. 598). ***Exploratory research aims to generate new empirical evidence where that might be lacking***, generate relevant concepts, and plausible hypotheses or propositions for future studies (Creswell, 2007).

The literature review chapters highlighted the dearth of research in particular areas of technology transfer through intermediaries, especially in developing countries (Intarakumnerd and Chaoroenporn, 2013), and showed that the existing theories of both technological learning and technology intermediaries do not adequately explain the phenomenon. According to Creswell (2007), the exploratory study is the most appropriate where the phenomenon is not well understood or there is dearth of research (see also Easterby-Smith *et al.*, 2002). Given the current lack of clear understanding about who technology intermediaries are (Howells, 2006), and the contextual nature of technology intermediaries (Clarke and Ramirez, 2013), an exploratory approach is deemed the most appropriate, and is the most widely adopted research approach found in the literature review for this topic. Due to its exploratory nature, a qualitative case-based research design has been suggested as the most appropriate (Creswell, 2007; Saunders *et al.*, 2007). The following section discusses this in detail.

#### **4.4 QUALITATIVE RESEARCH**

In general, there are three main research approaches for social science; qualitative, quantitative, and mixed approaches that combines both qualitative and quantitative (Creswell, 2002, 2007; Denzin and Lincoln, 2005; Guba and Lincoln, 1994). Several factors guide the choice between the different approaches such as the research problem, the researcher's experience, and the final audience (*ibid*). According to Myers (2000), a qualitative approach aims to "understand the social world from the viewpoint of respondents, through detailed descriptions of their cognitive and symbolic actions, and through the richness of meaning associated with observable behaviour" (Myers, 2000, p. 1). It uses and generates non-numerical data (Saunders *et al.*, 2007) and is particularly valuable when it focuses on naturally occurring, ordinary events in natural settings (Miles and Huberman, 1994). Most qualitative studies adopt an interpretivist paradigm (Denzin and Lincoln, 2005) as it allows researchers to explore the different views attached to the phenomenon being researched.

While quantitative research refers to counts and measures of things, qualitative research refers to the meanings, concepts, definitions, characteristics, processes, and descriptions of things (Berg, 2001). Qualitative research is emergent rather than pre-configured, and is used to develop a set of constructs that can be used in future research (Creswell, 2007; Miles and Huberman, 1994) if such concepts are not yet well established. In contrast, quantitative research methods measure predefined factors and do not allow for the emergence of new factors (Miles and Huberman, 1994).

A qualitative approach was selected for this study for a number of reasons. First, the factors that influence the functions of intermediaries along the transfer process have not been well established or defined in previous research, making qualitative data collection and analysis a key step in developing a set of constructs that can be used for future research (Miles and Huberman, 1994).

Second, the theoretical framework adopted for the study is qualitative. Technological learning and KBV emphasize the transfer of tacit technologies for technological learning (Figueiredo, 2003; Grant and Baden-Fuller, 1995; Lall,

1992). Quantifying technology transfer, though desirable, has been recognized as problematic, which is why most researchers use a qualitative approach (Shohet and Prevezer, 1996). For example, tacit technologies are partly non-tangible and are difficult to quantify (Grant and Gregory, 1997; Nonaka and Krogh, 2009).

Third, although the cases selected are informative for the posed research problem, there is a scarcity of quantitative statistical data available with cases regarding the research problem. This emphasises the selection of the qualitative approach to gather primary data for the research through talking to individuals involved on the transfer process through intermediaries.

#### **4.5 RESEARCH STRATEGY: A MULTIPLE CASE-BASED RESEARCH**

This study adopted a multiple case-based research strategy. The two main national and largely state-owned firms in the Omani oil and gas industry (namely PDO and OLNGL) were judgementslly selected as the cases. According to Steensma (1996), case-based research is often the most appropriate approach to study organizational learning through inter-firm relationships. Moreover, the study of technology intermediaries is contextual (Clarke and Ramirez, 2013), and lacks an established and common definition (Howells, 2006); in addition, the practices of technology transfer and learning vary from one environment to another (Figueiredo, 2001). These issues are why case-based research is the most adopted research strategy to examine technology intermediaries (e.g. Bessant and Rush, 1995; Clarke and Ramirez, 2011; Howells, 2006; Intarakumnerd and Chaoroenporn, 2013; Kilelu *et al.*, 2011).

Moreover, the research questions of this study are mainly 'how' and 'what' in nature, rather than 'how many' or 'how often'. Case-based research is superior at addressing 'how' or 'what' questions about past or current phenomena, particularly when it draws on multiple sources of evidence (Ragin, 2007; Saunders *et al.*, 2007). Case-based research is valuable when issues are not adequately understood, previous studies have produced contradictory results, phenomena being researched are new and need to be explored in their natural context

(Creswell, 2007; Kohlbacher, 2006), and when existing theories are weak (Rowley, 2002). As the case study is the preferred design for this research, two issues are of importance – the sampling (number and selection of cases) and the unit of analysis (Yin, 2014). Details on the unit of analysis, and the sampling are discussed in the following sections.

#### **4.6 UNIT OF ANALYSIS**

The unit of analysis is a critical factor in case study research. It could be an individual or group of individuals (Yin, 2014), a process (Figueiredo, 2001; Lin, 2003), or a system of action (Tellis, 1997).

As this study aims to examine the process of technology transfer and learning through intermediaries, and the factors that influence the functions of intermediaries along the five stages of the transfer process, the unit of analysis is the entire process as the respondents describe it. The study will identify the different functions performed by intermediaries along the five stages of the transfer process, and will investigate the factors influencing those functions. Taking the entire process as the unit of analysis has been adopted in various similar previous case studies (e.g. Bessant *et al.*, 2012; Clarke and Ramirez, 2013; Figueiredo, 2001; Howells, 2006; Lin, 2003). The next section explains the process of identifying and selecting the cases for the study – the sampling.

#### **4.7 SAMPLING**

Sampling refers to the process of selecting research participants or cases for the study (Saunders *et al.*, 2007). As Miles and Huberman (1994) described it, it is about choosing who to look at, where, when, about what and why (Miles and Huberman, 1994). As per Ragin (2007), case sampling is used to identify the larger category the case belongs to or represents. It is about “what my case is a case of?” (Ragin, 2007, p. 4).

Sampling involves two main techniques; probability-based (random) sampling and non-probability or judgemental/purposeful sampling (Berg, 2001; Ragin, 2007). These techniques provide a variety of methods that enable researchers to reduce

the amount of data that needs to be collected. This, in turn, reduces the resources needed for research by focusing on data from sub-groups rather than all possible cases or elements (Saunders *et al.*, 2007). Sampling in qualitative research differs from sampling in quantitative research (Patton, 1990; Ragin, 2007), and in this study a non-probability sampling technique was used.

Qualitative sampling is “purposive”, “judgemental” or “theoretical” (Berg, 2001; Patton, 1990), rather than random that aims at generating statistical significance (Huberman and Miles, 2002; Ragin, 2007). Samples (cases) for qualitative research are selected based on several features such as being “information-rich” (Patton, 1990, p. 169), “accessible and illuminative” (Yin, 2014, p. 26), “representative” (Ragin, 2007), a “very powerful example” of the phenomenon being studied (Siggelkow, 2007, p. 20), and “enable detailed exploration and understanding of the central themes and puzzles that the researcher wishes to study” (Ritchie *et al.*, 2003, p. 78).

A key feature of qualitative sampling is the small number of cases chosen for the study (Mason, 2010; Miles and Huberman, 1994). That is because the ultimate goal of most qualitative studies is not to provide a statistical significance or sample-to-population generalization (Ritchie *et al.*, 2003). Instead, it aims to generate a deep understanding of the phenomenon (Crouch and McKenzie, 2006; Huberman and Miles, 2002), that provides analytical generalization (Yin, 2014).

The second step of sampling in the case study is the selection of participants for the research. The snowball sampling technique was employed in this study to identify and recruit the participants within the cases for the data collection process. Snowball sampling is used mainly when it is difficult to identify participants (Saunders *et al.*, 2007). In such situations, researchers first identify key informants who, in turn, help to identify subsequent participants. The following sections explain the sampling process of this study.

#### **4.7.1 SAMPLING: IDENTIFICATION AND SELECTION OF HOST-CASES**

The first sampling step in this study was the identification and selection of the cases. The selection of the case is determined by the nature of the research

phenomenon (Dantas and Bell, 2011), contents of the case (Patton, 2002), which provide rich contents for the problem being researched (Figueiredo, 2003), the representation to a larger category (Ragin, 2007), and the accessibility – allowing access to its resources (Tellis, 1997). Accordingly, the case is purposefully identified and selected to gain an in-depth understanding of the phenomenon (Ragin, 2007; Ritchie et al., 2003).

This study adopts a multiple-case strategy of two cases and follows the “replication logic” for examining the cases (Eisenhardt, 1989; Yin, 2014). The replication logic is analogous to multiple experiments employed in a naturalist approach, and it allows the comparison of results obtained from multiple cases (cross-case analysis) (Yin, 1994), which enhances the validity and generalizability of results (Eisenhardt, 1989). Each case is treated as a stand-alone case and is examined through the same conceptual framework and with the same methodology and approach. According to Yin (2014), the results obtained from multiple cases are often perceived as more compelling, and the study is regarded as being more robust.

The multiple cases of this study are the two major and large national firms in the oil and gas industry in the Sultanate of Oman. These firms are Petroleum Development Oman (PDO) and Oman Liquefied Natural Gas (OLNG). They were established in 1962 and 1993 respectively. These firms are not only key players in the national economy (CBO, 2013), but according to key informants they are also key players in inward technology transfer. The two firms import different technologies of different scales and characteristics from different sources. They have a list of global, regional and local suppliers of technologies, some of which are intermediaries – agents and consultants. The background of these two firms will be presented in the following chapter when presenting the background of the cases. The selection of the two firms is based on them being representative of firms that possess weak internal R&D capacity and are isolated from most technological sources. Moreover, due to their extensive experience in technology transfer through intermediaries, they provide rich contents about the problem being researched. In addition, they are valuable examples of ‘technology transfer through intermediaries’ because they are isolated from most technological sources.

The sampling of the two firms (cases) went through several steps. First, insights from the literature review highlighted the main theories and most relevant information to gather during fieldwork in order to answer the research questions. This helps limit the choice of cases to those that contain the content and experience to answer the questions. Second, several discussions with key informants at several potential firms were undertaken to better understand the technology transfer practices, and to identify the most suitable cases that provide the content to answer the research questions and achieve the goals.

Based on the literature, a tentative definition and categorization of intermediary and intermediation functions was developed, which was presented to key informants. Accordingly, they helped in nominating the technology intermediaries involved at different stages of the technology transfer process.

#### **4.7.2 SAMPLING: SIZE AND THE IDENTIFICATION OF RESEARCH PARTICIPANTS**

Participants for this study from the two case firms were identified by a snowball-sampling technique that generates subsequent participants based on the suggestions of preceding participants (Saunders *et al.*, 2007). The first step for selecting participants was the identification of key informants. According to Kumar *et al.* (1993), when the contents required for research cannot be expected from representative survey respondents, the key informant approach is appropriate. The key informants were judgementally selected as knowledgeable, able and willing to share their experiences about the problem being examined. Through formal and informal communications, key informants were first identified at both firms – PDO and OLNG. Those informants helped in piloting the study and testing the reliability of the proposed research questions, as well as proposing subsequent participants. Every participant was asked to nominate the next one based on certain characteristics and criteria.

There are some issues that required more consideration during the participant sampling. These were the number and recruitment process of participants and response bias of participants. The number of participants for this study was not determined prior to the fieldwork. Instead, the “saturation principle” was employed to determine the number of participants (Denzin and Lincoln, 2005;



Mason, 2010). This principle suggests that researcher continues collecting data from participants until it is realized that more data does not necessarily shed any further light on the issue under investigation. This principle is highly recommended for qualitative studies (*ibid*). The main argument of this principle is that more participants or more data do not necessarily mean more or better information; thus the focus is on the quality of data rather than the frequency of occurrences.

Saturation in this study was realized and determined by two measures. First, by realizing the point of diminishing return of information (Mason, 2010). This point indicates that more participants do not necessarily provide different or new inputs to the study. To ensure the research has reached this point, five more participants were taken after the realization of the diminishing point, which confirmed the argument of saturation. While acknowledging that every extra respondent might add new insights, it was confirmed that new insights do not necessarily add significant value to the overall study.

The second measure for the saturation was the achievement of the objectives of the study. The objectives of the study were used as guidance for the fieldwork, and their achievement announced the end of the fieldwork. However, after the actual fieldwork, the researcher remained in contact with participants to confirm or clarify results.

To avoid the response or recruitment bias and to ensure the validity and relevance of data, this study proposed selection criteria for participants. It was suggested that any site-based qualitative researchers should define certain characteristics that help in defining and bounding samples, as well as ensuring the relevance of a sample to the research (Arcury and Quandt, 1999). For this study, several criteria were defined for nominating participations. These criteria were presented and explained for the present participant in order to help in nominating the subsequent. The present participant was informed about the research and its objectives, in addition to the minimum knowledge and experience expected from the next participant. Participants were expected to be knowledgeable about the topic, have been involved in technology transfer projects through intermediaries

within the company, possess a minimum level of language and technical capacity to communicate his/her experience, and willing to participate. Such criteria were also adopted in Kumar *et al.* (1993) as a global measure to assess the competency of the participants for examining the phenomenon.

To avoid participant bias, participants were recruited from different departments across the two firms and at three different levels of hierarchy; managers, section head (team-leaders) and front-line engineers or technicians. In addition, respondents were of mixed nationalities and experiences. This mix assured that most or all insights that might be important were revealed, which in turn increased the validity and reliability of the results and multiplied the number of views considered in the study (Ritchie *et al.*, 2003). The different organizational levels provided the opportunity to collect “rich data from people in various roles and situations” (Myers, 2008). Having participants from different levels and departments widens the experience provided to explore the problem and to triangulate the results as well.

Following the above steps, the total number of participants included for this research was 48 from the 2 firms of PDO and OLNG, besides three retired senior managers from PDO and four intermediary individuals as shown in Table 4-2 below:

**Table 4-2: Number of Participants from the Two Firms and at Different Hierarchies**

Firm	Managers	Section heads/ team leaders	Engineers/ Technicians	Key informants	Retired managers	Total
PDO	4	5	21	2	3	35
OLNG	3	3	12	2		20
Intermediaries						4
Total						59

Having selected the cases, identified the appropriate sampling technique, and defined the sample size, the next step was to contact them for the actual research – the recruitment. The actual recruitment of participants for this research went through the following steps:

1. Ensured the acceptance and free willingness of participants to participate;
2. Shared the information sheet with the willing participants;
3. Agreed on time and place for the actual meeting. The preference of participants on where and when they feel comfortable to participate was considered;
4. After the interview, the researcher asked participants to nominate the next participant who in turn is provided with the relevant information to be able to decide whether to participate or not.

#### **4.7.3 ACCESSING THE CASES FOR THE STUDY**

One of the important steps in case-based research is gaining access to the case and its resources (Tellis, 1997; Yin, 2014). Gaining access to the case/s involves a range of ethical, social, economic and political considerations of which researchers should be aware (Yin, 2008). The ethical consideration is one of the early steps for any research that involves human or animal interactions (Saunders *et al.*, 2007). This research involves human interactions and thus the study was reviewed and gained ethical approval from the ethics committee of the university. This approval is thought to add credibility to the research in front of the respondents as high-class academic research since it has been reviewed and approved by qualified personnel (*ibid*). For this study, different considerations were carefully noted prior to accessing the firms. These include:

1. Getting the ethical approval of the university to start implementing the research;
2. Identifying key informants in the two cases;
3. Getting a supporting letter from the sponsor of this research. In the local context, this letter adds more credibility to the research and researcher, especially when the sponsor is a government body;
4. Establishing an official communication channel with the cases and gaining official approval to interview employees and access other resources, where possible, such as documents related to the research;
5. Agree to the non-disclosure-agreement (NDA) regarding the type of information that can be published or data that might be accessed;

6. A focal point was allocated for the research within the firms, who was responsible for facilitating access to different possible resources within the case company.

#### **4.7.4 SAMPLING: ETHICAL CONSIDERATIONS**

Ethical considerations are a crucial element in any research across all steps of implementation (Kvale, 1996; Miles and Huberman, 1994). There are some ethical considerations of which a researcher needs to be aware when selecting the case for the study. This study has considered several ethical issues including, but not limited to, the following:

1. Provide the right details about the research – the purposes or the objectives of the study;
2. Provide all relevant information necessary for the cases to take a decision whether to or not to host the intended research;
3. Protect the confidentiality of the information and data provided by the host-case;
4. Not to allow or accept to use the information for any purposes other than that for which it was originally gathered;
5. Not to apply pressure, directly or indirectly, on the case to host the research. The case should be free to decide to host or not;
6. A key request from both cases was not to specify their identity on the presentation of the final report, nor to present any data that was considered sensitive or confidential according to their data categorization, even if data seem not to be sensitive from the researcher's point of view. This study followed the suggestion of Oates Creswell (2002) and Kvale (1996) to keep the identities of the participating organizations anonymous. Accordingly, pennames such as ALPHA, and BETA were used to denote different firms in order to maintain the anonymity of the two firms in the report.

Likewise, the following ethical consideration was noted with regard to individual participants:

1. All participants were provided with the information sheet that informed them about the objectives of the research in addition to the roles of participants within the research and the data analysis and presentation;
2. For different reasons, such as the type of data being sought from participants through the interviews (which are not sensitive even by the measures of participants), and due to some cultural aspects, this study did not require a written consent form. However, an oral consent was gained, and it was recorded as part of the interview. When a participant refused to be recorded, intensive notes were taken during the interviews to avoid missing any important information;
3. Reminded participants before the interview about the overall goals of the research and the type of information to be collected throughout the interview;
4. Reminded participants about their rights to stop at any point, or to completely withdraw from the participation;
5. Not to apply direct or indirect pressure on participants to be involved in the research. A free-willing policy was employed that allows participants to freely accept or refuse to participate in the research;
6. Assuring participants about the anonymous and confidential nature of the final report (thesis). This anonymity was found to encourage participants to freely express their views about the topic without fear of being caught or criticized by the management if their views, for example, disagreed with management views. The anonymity was found to enhance the validity of the information gathered during the interview.

Having selected the case and gained access to participants, the next step is to start collecting the data. This is discussed in the following section.

#### **4.8 DATA COLLECTION**

Case-based research collects data through different quantitative or qualitative tools (Ragin, 2007). This study gathered primary data through semi-structured interviews supported by available supplementary documents such as annual reports and other documents. Following the suggestion of Yin (2003) and

Kohlbacher (2006), a pilot study was conducted prior to actual data collection as follows.

#### **4.8.1 PILOT STUDY**

Building on the information gathered during the literature review, a tentative conceptual framework was developed, which was tested with several sources. First, the research supervisors reviewed the preliminary framework that would guide the actual fieldwork. Their comments were reflected upon and the framework was amended accordingly. In addition, some opening interview questions were also presented and discussed to ensure the data gathered through those questions was relevant and led to provide answers to the research questions.

Second, colleagues were a helpful source for commenting on the initial conceptual framework. Third, in addition to telephone interviews with key informants at the proposed hosting cases, short visits to the firms were conducted. The interviews aimed to assess if the key informants understood the concepts and questions in the way meant by the researcher. Key informants provided helpful comments on organizational language to help match it to concepts of the literature. The pilot study helped refine the data collection plans with respect to both the content of the data and the procedures to be followed on the fieldwork.

#### **4.8.2 DATA COLLECTION: SEMI-STRUCTURED INTERVIEW**

A semi-structured interview was the main data collection tool. It was noted that interviews are the dominant data collection strategy for interpretive research and are often applied in case study research (Golafshani, 2003; Kvale, 1996).

Interviews started with initial opening questions about the research topic. Based on the responses of the interviewee, the interviewer followed up on the response and sought new information through probing questions. Probing questions allowed the exploration of unexplored areas within the research topic, which allows for gathering more details and deeper understating of the topic from the perspectives of the interviewees.

There are several reasons and advantages for employing semi-structured interviews for the data collection of this study. First, the study's research questions

are more 'what' and 'how', which are more open-ended. According to Eriksson and Kovalainen (2008), when the questions are 'what' and 'how', semi-structured interviews are the most appropriate for answering via open-ended questions. Second, given the exploratory nature of the study, semi-structured interviews allow for the exploration of unexplored areas of a research topic (Kvale, 1996; Saunders *et al.*, 2007). Third, semi-structured interviews are a useful tool for understanding the meanings that interviewees attribute to various phenomena through probing questions (Kvale, 1996; Saunders *et al.*, 2007). Fourth, other tools of data collection, such as surveys or questionnaires, often collect data for known constructs and variables, but this is not possible with most exploratory studies that aim to define those constructs for future research. Fifth, some information about the firms is confidential, and rarely is disclosed to external researchers. For example, firms are reluctant to disclose information such as their budget for training, capacity of human resources or their business strategies to external parties such as researchers. Through open conversations, researchers can extract necessary information by talking to company employees.

Accordingly, for this study semi-structured interviews are suggested to prove more fruitful in gathering and generating valid information than the use of other data collection approaches. While semi-structured interviews were the key data collection tool for this study, they were supplemented with documents and conversations with experts outside the firms. Importantly, the open and probing questions for the interviews were ensured free of any influential terminologies and not leading answers from participants, or guiding in a certain direction. Moreover, the questions were reflective, in which the interviewer changes or modifies the questions for subsequent interviews based on the outcome of previous ones and so on, in order to achieve the objectives set for the data collection. For instance, the next question might explain, confirm or reject results gained by previous questions. Such considerations for the questions reduce bias in responses and the reliability of the information gathered.

Since the preferable place for most interviewees was the working offices, the researcher of this study conducted site visits to the offices prior to the actual interviews. This is to get familiarise with the working environment and to get to

know potential respondents, as well as spread awareness among a wider community of employees about the research and its objectives in order to win their willingness and support. Moreover, the visits helped to ensure the suitability of the environment for the interviews.

During the interview, the researcher first thanked the interviewee for agreeing to participate and reminded them about the objectives and purposes of the research, the proposed length of the interview (one hour), their right to withdraw at any time without needing to justify, and the anonymous feature of the final report. The researcher also assured the interviewees about the confidentiality of information gathered. This assurance made interviewees feel comfortable so they could express their real experience. Moreover, the researcher asked for the interviewee's permission to record the interview. Upon acceptance, the researcher recorded the interview and took notes during the interview.

Interviews lasted for a minimum of one hour and in some cases considerably longer. Intensive notes were taken during the interviews, with important responses written verbatim. After finishing the interview, the researcher summarized the information and explanations provided by the interviewees so they could evaluate their understanding and interpretation by the researcher, and correct if necessary. This helped ensure the researcher had understood what the interviewees meant to say and validated the information gathered and the interpretation made by the researcher (Saunders *et al.*, 2007).

There are two main threats to the internal validity of data collection that might occur during the interview. These are the influence of the researcher on respondents and the behaviour of the respondent towards the questions (Miles and Huberman, 1994). The influence of researchers is mainly located in the way the interview questions were framed and the language used to question the interviewees. These issues were considered during the design of the questions. In addition, respondent bias was eliminated as much as possible through different means. First, and most important is the free willingness to participate or withdraw from participation. No direct or indirect pressure was made on participants to accept to participate. Second, criteria were developed for nominating participants



and were applied equally for all potential participants. Third, assuring them about the anonymity and confidentiality of the report, and that there would be no reference to identity or job titles. Fourth, getting to know participants and developing a personal relationship with potential participants. These visits prior to the fieldwork allowed the researcher to become familiar with the work environment and give the participants the chance of getting to know him.

#### **4.9 DATA ANALYSIS**

Data analysis is a systematic process of searching and arranging the data gathered from the field so that fruitful meanings and understandings can be developed from the raw data (Boyatzis, 1998; Burns, 2000). According to Eisenhardt (1989) analysis of qualitative data is the most difficult section of a case study. It challenges researchers on how to condense complex and large amounts of data into a meaningful format that generates a convincing argument for readers (Easterby-Smith *et al.*, 2002).

Qualitative data analysis starts at the research design stage (Miles and Huberman, 1994). Prior to the data collection process, researchers think about how the data being collected will be analysed in order to answer the research questions, achieve the objectives, and produce fruitful meanings and interpretations. According to Easterby-Smith *et al.* (2002), qualitative researchers adopting an interpretive paradigm do not draw a distinction between data collection and data analysis or data interpretation, as the three go side-by-side. Analysing data while being collected allows researchers to start analysis early and take advantage of flexible data collection; it also gives them the freedom to make adjustments in research during the data collection process (Eisenhardt, 1989). Such adjustments include changes in the conceptual framework as the data collection progresses, directing more attention towards particular concepts, or adding and deleting interview questions.

Qualitative data analysis is not a linear process: it is more an iterative one that moves back and forth as necessary between data and their interpretation and conclusions along the analysis process (Braun and Clarke, 2006; Miles and Huberman, 1994). This back and forth iteration along the writing process allowed

the gaining of an in-depth understanding and capture the themes and patterns within the data.

Empirical data of this study was analysed using a “qualitative content analysis” approach, in which meanings are drawn by interpreting the contents of the data (Holdford, 2008; Miles and Huberman, 1994). The following section explains how the qualitative content analysis approach was employed for this study.

#### **4.9.1 QUALITATIVE CONTENT ANALYSIS**

Content analysis is “a technique that systematically collects and analyses the makeup and exchange of communication through various visual, auditory, and print media” (Holdford, 2008, p. 173). It is divided into quantitative and qualitative analysis (Mayring, 2000). Quantitative content analysis does not take into consideration the context or the meaning of the words (Morse *et al.*, 2002) and relies on counting the number or frequency of occurrences of particular phrases or words (Easterby-Smith *et al.*, 2002) to generate frequency counts. However, it was argued that the number of occurrences of a phrase does not necessarily mean the phrase itself is more crucial (Braun and Clarke, 2006). These issues make quantitative analysis less meaningful to qualitative researchers adopting semi-structured interviews as a main tool for data collection. Through this tool, the phrases are not expected to occur frequently, as the questions vary from one respondent to another.

In contrast, qualitative content analysis stresses interpretation over quantification of data, and focuses on the influence of context on the research process (Holdford, 2008). Qualitative analysis tends to be more exploratory in nature; less structured and has the capacity to explore questions unanswerable by more quantitative analysis methods (*ibid*). It allows making inferences by objectively interpreting meaning from the contents of text data (Mayring, 2000), and relating them to the whole in order to gain a deep view of the phenomenon (Creswell, 2002). The results of qualitative analysis are often presented in illustrative quotations (Wilkinson, 2010).

From the contents of the primary and secondary data, themes or factors are identified inductively or deductively, or a combination of the inductive and deductive approach (Braun and Clarke, 2006). The theme “captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set” (p. 82). Importantly, themes are not identified based on the frequency of occurrence of a phrase or word. Researchers identify themes judgementally from the words of participants (*ibid*), thus in qualitative research the researcher is part of the research process (Creswell, 2002). From the new data, themes can be identified inductively based on the new data without trying to force them on prior developed themes or constructs – data driven. They can also be identified deductively, in which themes are identified based on a prior thematic framework – theory driven.

The data collected in this study includes primary data from interviews supplemented by secondary data from reports and documents. Each interview was transcribed immediately after the interview session and written up afterwards by the researcher himself. After recording each interview (some participants refused to be recorded thus intensive notes were taken), the researcher listened to the recordings several times. This was in order to find out the main contributions of the interviews and presented them in quotations, which are clustered and matched together in order to gain a holistic understanding of participants' views. According to Kvale (1996), the transcription style is verbatim or meaning, depending on the use of the transcription for the analysis. Whichever style is adopted, it should retain the information needed from the verbal account, and in a way that is ‘true’ to its original nature (Braun and Clarke, 2006).

This study adopts the meaning and verbal transcription (rephrasing) of interviews and covers the sections of the interviews that are most relevant to the research problem and that could provide strong evidences of the findings. Some content of the interviews were transcribed verbally into quotations. These quotes were emphasized by the interviewees with intensity and significance, thus were used where appropriate in the analysis process. These quotes are presented in the final report in order to “bring in the voice of participants in the study” (Creswell, 1998,

p. 170), which has been considered to be an essential element of an interpretive research approach.

While the meaning transcription approach was adopted in many cases, meanings were checked with interviewees to ensure they captured the message intended. This was done during and after the interviews through an email or telephone call, or even another interview. Where further clarity or additional information was required, participants were contacted again.

As primary data was collected mainly through semi-structured interviews, the interview questions were not exactly the same with each participant as some interviews clarified or complimented others. However, the focus and the aim of the interviews across all the interviews was the same, even though the questions were different.

In addition, the hierarchal level of participants dictated the selection of interview questions and the type of data that could be gathered. For instance, data related to the strategic direction of the firm towards learning or selection of suppliers (intermediaries) is better collected from participants at the management level than from front-line engineers. In contrast, the data regarding the influences of the direct interactions with intermediaries during the transfer process is better collected from engineers who are in the field operating the technologies, as they are the individuals interacting with intermediaries. However, this does not mean that similar information could not be gained from all participants, since current managers had worked as front line engineers and were able to express and share their past experiences.

From the several quotations produced by the data transcription and the secondary data, the initial themes (factors on the conceptual framework) of this study were reviewed in light of the new data – deductive analysis. Initial themes in this study were the concepts (factors) that were derived from prior studies as factors influencing the functions of intermediaries along the transfer process. These include the proximity, specialization, technology and user of the technology. After the fieldwork, themes were reviewed and identified via deductive and inductive approaches. By following the suggestion of Miles and Huberman (1994), and Braun

and Clarke (2006), that qualitative researchers should employ inductive and deductive approaches to content analysis, both approaches were employed.

This study started identifying themes from the data deductively, in which the new data is analysed with respect to the initial concepts of the framework. Themes within the deductive approach are described according to the conceptual framework. This approach helps to support or reject existing themes of the framework and guides the initial analysis and interpretation of new data based on pre-existing expectations, while opening the door to identify new themes from the empirical data. As the data analysis progresses, a more inductive approach was employed to refine the initial themes and identify new emerging themes or new understanding to the research problem.

New themes are identified judgementally while participants stress or highlight the significance of any factor that might influence the researched phenomenon. Although the number of occurrences of a theme in the interviews was not the main tool to identify themes, it was used as guidance and a hint to note the emergence of a new theme.

This content data analysis (transcribing through to thematizing) continues several times, trying to look at the data from different views in order to find out possible new input to the analysis. The researcher was shifting back and forth between data collection and data analysis, which enabled him to move with the data and unfold the unique and untold aspects of the researched phenomenon. The findings are reviewed with respect to literature without limiting possible findings that might disagree with the literature. The process stops after the researcher realized the marginal improvement of reading and analysing the empirical data became small, which is the theoretical saturation.

As this study was implemented on two cases, the above data analysis procedures were replicated for the data collected from those two cases. Eisenhardt (1989) suggested two levels of data analysis for a multiple case study. These are the "within case analysis", and searching for "cross-case" patterns. The "within case" analysis involves detailed analysis and write-ups for each case. The empirical data of each case was analysed separately and presented on the within case analysis

report. According to Eisenhardt (1989), the main idea of the “within-case analysis” is for the researcher to become familiar with each case as an individual entity. Moreover, it allows the unique patterns of each case to emerge before comparison and generalization can be made across cases.

After analysing each case separately and following the same approach (replication logic), the results are compared in what is called “cross-case analysis” in order to identify similarities and differences between cases, and search for patterns before generalizations can be made. The results achieved from the individual cases are compared in order to identify whether they support each other or otherwise. Where the findings from the two cases confirm each other, it enhances confidence in the validity and generalizability of the findings (Eisenhardt, 1989; Voss *et al.*, 2002); i.e. “The finding is stronger and better grounded” (Eisenhardt, 1989, p. 541).

In contrast, when the findings of the two cases contradict each other, the study searched for explanations for the different results, which can often provide an opportunity to refine and extend the existing theory. From the cross-case analysis, conclusions are drawn and reviewed in light of the existing literature. This step involves searching for literature that supports or conflicts with findings, and to find reasons for the agreement or otherwise (Eisenhardt, 1989).

Finally, the findings are presented in the report (thesis), which is a linear description of the research journey right from the beginning through to the conclusions and suggestions. However, prior to writing the final results, the findings and conclusions were reviewed, where possible, with several participants from the two cases. This was to ensure the soundness of results, and ensure that the researcher captured the intended messages of participants. In fact, consulting participants to ensure the quality of data collection was employed throughout the data collection process. Following the interviews or document reading, the researcher consulted participants to ensure the understanding of the researcher was exactly what was intended. Clarifications and amendments were made to the data collected as needed, and the final themes or results were reported.

Having described and discussed the details of the data analysis technique employed in this study, the next section is to ensure the quality of the research and the results obtained. That is to ensure the research and findings withstand the rigours test.

#### **4.10 RESEARCH RIGOURS**

All scientific research is subjected to rigour tests (Easterby-Smith *et al.*, 2002; Morgan, 2012). However, there is an on-going debate on the type of tests that are applied on qualitative and quantitative research (Kvale, 1996; Morgan, 2012). According to Long and Johnson (2000), a rigour test has traditionally focused on the assessment of reliability and validity of the research. In contrast, Lincoln and Guba (1985) perceive validity and reliability as two faces of the same coin and assert that validity does not exist without reliability, as a demonstration of the validity is sufficient to establish the reliability. Accordingly, Guba and Lincoln (1994) suggest the use of other measures such as dependability, credibility, transferability and conformability. Morgan (2012) argues that the evidence of a qualitative case study is combined to create an internally valid account; that is consistent, coherent, and credible.

While accepting the reliability and validity tests for qualitative research, Golafshani (2003) argues that these tests have different meanings for quantitative compared with qualitative research, thus they have to be redefined in qualitative research. According to Golafshani (2003), the research paradigm dictates the meaning of the rigour test. Healy and Perry (2000) asserted this view as the quality of a study in each paradigm should be judged by its own tests (Healy and Perry, 2000). Likewise, Myers (2000) argued that the aim of qualitative research is to discover meaning and understanding rather than to verify truth or predict outcomes. She continues, this type of research is based on its own specific epistemological foundations and has its own perspective on ways to contribute knowledge to the community and society (Myers, 2000).

The above debates show the lack of agreement amongst researchers on how to ensure the rigour in qualitative research. This lack has been clearly highlighted and stated by Roulston (2010) when saying: “there is no consistency in the terms used in relation to the assessment of ‘quality’ of qualitative interview research” (Roulston, 2010, p. 201). The different terminologies such as reliability, credibility, and validity that have been used might only add confusion to researchers as they often refer to the same thing.

Leaving the endless debate on the appropriate tests for ensuring the rigour of qualitative research, the four main rigour tests of reliability, credibility, validity, and generalizability were ensured in this study as follows:

#### **4.10.1 RELIABILITY**

A research is said reliable if it is possible to repeat it with the same participants and under the same conditions, employing similar methods and achieving the same results (Burns, 2000; Gray, 2009). However, there is lack of agreement among qualitative researchers in assessing reliability in qualitative research particularly when reliability is understood as repeatability of research (Long and Johnson, 2000). The interpretivism paradigm, which is adopted for this study, emphasizes that there are multiple views of the truth to be discovered (Easterby-Smith *et al.*, 2002; Miles and Huberman, 1994). This basically means different researchers might discover and interpret different views from the same respondents and for the same cases, making the repeatability of research difficult to produce the same results.

This is highlighted by Long and Johnson (2000) when they argued “interpretive researchers ought simply to accept that reliability is unlikely to be a demonstrable strength of their work” (Long and Johnson, 2000, p. 31), referring to the repeatability of research. Similarly, Saunders *et al.* (2007) reported that it is almost impossible to reproduce a research when it is conducted from the interpretivism paradigm. Moreover, as the data was collected through interviews that involved human interactions, human behaviour changes continuously making the reproduction of the research or the achievement of the same results difficult if not



impossible. In contrast, Morse *et al.* (2002) argue that reliability is applied to all types of research.

This study adopts the proposal of Long and Johnson (2000), Morse *et al.* (2002) and Morgan (2012) *on monitoring consistency and coherence as a sign of the reliability of qualitative research*. The consistency of research refers to “ensure that data collection is undertaken in a consistent manner free from undue variation which unknowingly exerts an effect on the nature of the data” (Long and Johnson, 2000, p. 31). *Simply, reliability in qualitative research is concerned more with the stability in data collection than repeatability of the research*. Accordingly, the reliability of this study was ensured through the following steps:

1. Explained and justified the selection of every step in the research – questions through to reporting (themes, interview questions, sampling, data collection and analysis, reporting);
2. Developed structured data collection and analysis procedures and explained how conclusions were drawn;
3. Repeat the research via the replication logic on two individual cases;
4. The continuous movement back and forth between objectives, questions, data collection and data analysis to ensure they all consist and yield the same outputs

#### **4.10.2 CREDIBILITY**

Credibility of research is concerned with *the ability of researchers to provide adequate and convincing evidence in order to support the findings* (Myers, 2008). It is basically the ability of researcher to report the findings in a way that indicates they are sound and robust (Maylor and Blackmon, 2005). Long and Johnson (2000) perceive the credibility of research in the ability to show strong links between the different parts of the research, “the plausibility of the findings is reliant upon the interpreted, analysed data being recognisably drawn from the raw data, and is demonstrated partly by evidence of stringent efforts to ensure this” (Long and Johnson, 2000, p. 32). Different measures have been used to ensure the credibility of this research:

1. Adopted the most suitable and appropriate research design that allowed the research questions to be answered and achieved its objectives;
2. Piloted the study with various sources prior to the actual data collection process to ensure correct understanding of the research;
3. Collected data from different sources including participants from different firms and different hierarchical levels, across different departments and included locals and expatriates;
4. Validated the data collected on a continuous basis by reviewing the data with its sources to ensure a correct understanding was gained in the way it was intended;
5. Adopted an iterative (moving backward and forward) data collection and analysis process;
6. Supported the finding by quotations of the different respondents;
7. Analysed data for each case and compared results across cases;
8. Continuously discussed the findings and progress with supervisors;
9. Trained myself in interviews and note taking skills.

#### **4.10.3 VALIDITY**

Validity of research is divided into two levels; external and internal validity (Saunders *et al.*, 2007). External validity is the extent to which the results of a research can be generalized to other situations (ibid). Generalization of research findings in qualitative research is analytical or contextual rather than statistical where a sample-to-population generalization is aimed (Kvale, 1996; Ritchie et al., 2003). Accordingly, some researchers argue that assessing external validity is not relevant to all qualitative research (Krefting, 1991), which in some cases subjects the qualitative research to criticism. A proposed way of avoiding that criticism is to highlight throughout the report that the aim of the study is not to produce statistical generalization rather than to gain an in-depth understanding of the phenomena being examined (Saunders *et al.*, 2007).

Internal validity, on the other hand, refers to the extent to which tools used to collect data such as concepts and questions, measure and assess what they are intended to do (Saunders *et al.*, 2007). Different steps are followed to ensure the internal validity of research including:

1. Ensured the match between the different parts of the research – questions, objectives, methodology, data collection and analysis;
2. Identified a tentative list of themes or constructs to develop an initial conceptual framework that guided the empirical data collection and analysis process;
3. Operationalized and understood themes according to the existing theories, and ensured they match the research objectives and questions;
4. Developed a list of interview questions and aligned them with the objectives, the questions and the objectives of the research;
5. Shared the themes and interview questions with different expertise such as supervisors, colleagues, and key informants;
6. Piloted the study with five key informants at the host-cases to ensure the questions and concepts are understood in the way the researcher intended;
7. Refined the themes and the questions based on feedback provided by different sources;
8. Reviewed the language and terms used for the interview questions in order to ensure a natural response by ensuring questions did not guide or lead the response of participants;
9. Develop different skills related to interviews and data collection;
10. Ensured participants understood the question in the way intended by the researcher, and the researcher understood the response in the way intended by the participants;
11. Tried as much as possible to be neutral during the interview and not to influence the response of participants;
12. Conducted concurrent data collection and analysis so the data collection is guided by the findings of each other;
13. Developed a structured data analysis procedure and explained how conclusions were drawn (from within-case to cross-case comparison);
14. Shared analysis (interpretations) of the data with the respondents, who had the opportunity to discuss and clarify the interpretation and contribute new or additional perspectives;
15. Contacted respondents for further clarifications whenever required.

#### 4.10.4 EXTERNAL VALIDITY: GENERALIZABILITY OF RESEARCH

The second validity test of research is the external validity or generalization. Generalizability of a research refers to the extent to which the findings of the research are applicable to other settings (Saunders *et al.*, 2007). Generalizability was highlighted as not being a core goal of qualitative case study (Myers, 2008). Instead, the goal is to gain an in-depth understanding about the phenomenon in its natural context rather than to achieve statistical generalization (Creswell, 2002; Myers, 2008; Yin, 2008). A case study is meant for discovery not for justification; “for the formation of evidence-based concepts, for the development of measurement structures” (Morgan, 2012, p. 671). Creswell (2002) argued “reliability and generalizability play a minor role in qualitative inquiry” (p. 195), and the case study is not meant to represent the world but to represent the case (Denzin and Lincoln, 2005; Morgan, 2012).

The generalization that can be achieved from a qualitative case study is an analytical generalization (Easterby-Smith *et al.*, 2002). The knowledge produced through a qualitative interpretive research can be generalized through its relevance to other settings rather than open generalization (*ibid*). It is the extent to which the findings from one study can be used as a guide to what might occur in other similar situations (Kvale, 1996). According to Morse *et al.* (2002), such generalization often develops from a single study to one that is similar, rather than from a single study to a population. Accordingly, analytical generalization is ensured in this study through the following:

1. Developed a detailed descriptive report with all steps that were followed;
2. Defined the specific context of the study;
3. Employed a multiple case strategy by adopting the replication logic;
4. Conducted within-case and cross-case analysis;
5. Reviewed findings in light of the previous studies and theories, and compared them to highlight the similarities and differences and to provide explanations;
6. Develop a new framework with existing and emergent factors that can be used in future research.

#### **4.10.5 TRIANGULATION**

One approach to increase the validity and accuracy of a research is through the triangulation process. Triangulation is “the use of two or more sources of data or data collection methods within one study in order to help ensure that the data are telling you what you think they are telling you” (Saunders *et al.*, 2007, p. 614). Triangulation in a case study approach is often achieved by using multiple sources of data (Yin, 1984), which might include data gathered from different cases, and within the case from different participants at different positions, from different departments and with different work experiences, in addition to documentary or archival data analysis (Guion *et al.*, 2011). Any of these approaches of triangulation can be used and would support the principle in case study research that the phenomena under research is viewed and explored from multiple perspectives (Baxter and Jack, 2008).

In this research, triangulation was achieved through the following:

1. Employed a multiple case study where data is collected from different representative firms of the industry;
2. Collected data from different respondents at different levels of hierarchy, from different departments, with different work experience and different nationalities;
3. Conducted interviews with three retired senior managers from PDO. They provided external and neutral views to the researched problem. They helped to confirm, reject and clarify results obtained from the field;
4. Conducted interviews with four intermediaries to validate the opinions of participants from the two cases regarding the functions of intermediaries and the factors that might influence their functions;
5. Reviewed data from supplementary sources such as documents, annual reports or other notes provided by the firms or individual participants.

#### **4.11 REPORT AND CONCLUSIONS**

The last step in any research is to draw conclusion(s) and report those to readers. The final report aims to inform various readers about the significance and

trustworthiness of the findings (Kvale, 1996). It should present the findings and reflections of the researcher on the findings to draw conclusions. The final report of this study includes both the findings and thoughtful reflections on those findings. The conclusions were drawn mainly after conducting the two levels of analysis for the empirical data – within case and cross-cases.

#### **4.12 SUMMARY**

Central to this study is examining how technologies are transferred through intermediaries, what factors might influence the transfer process, and how intermediaries influence user's technological learning. For this, this study adopted a qualitative multiple case study. The empirical data was mainly collected through semi-structured interviews with 48 participants from the two main firms in the Omani oil and gas industry, namely PDO and O LNG, at different levels of the case study firms' organizational hierarchy, across different departments, and include both Omanis and expatriates. The primary and secondary data were analysed interpretively via the qualitative content analysis approach over two levels, within cases and cross cases. Finally, ethical and rigour considerations for this research were all presented and discussed to ensure the quality of this study.

## 5 THE CASE STUDIES

### ***5.1 INTRODUCTION***

This study examines the influences of technology intermediaries on technology transfer and technological learning of firms that are (a) isolated from original sources of technologies and (b) possess weak internal technology production capacity. This will be achieved by mapping out the different functions of intermediaries operating in the Omani oil and gas industry, examining the factors influencing the functions of intermediaries along the transfer process, and analysing how that influences firms' learning. The previous chapter laid down the research design for this study. This chapter presents the background about the country, the cases selected for this study, the sector within which the two cases operate, and justifies the selection of the cases and the sectors.

The chapter starts by presenting an overview about Oman, its geographical locations, the national learning system, and how its location influences its learning. The second section presents background about the oil and gas industry, the context within which the selected cases are embedded. Finally, backgrounds about the two cases are presented. The two cases are the two major national and largely state-owned firms of the Omani oil and gas industry, namely Petroleum Development Oman (PDO) and Oman Liquefied Natural Gas (OLNG).

### ***5.2 SULTANATE OF OMAN: AN OVERVIEW***

The Sultanate of Oman is an oil-dependent country that is located in the southeast of the Arabian Peninsula, overseeing the strategic marine gate known as the Strait of Hormuz. The national economy is largely based on oil and gas revenue that dominates nearly 84.7% of the total government revenue (NCSI-Oman, 2013). The country also possesses weak technology production capacity (TRC, 2010; UNESCO, 2009), and, as such, the activities of the oil and gas sector rely heavily on external sources of technologies. This gives strong influences of the external sources of technologies on the Omani economy, thus developing internal technology production capacity becomes crucial for the country.

Geographically, Oman is located in a technologically lagging region (the Arabian gulf) away from most of the world's technological sources (UNESCO, 2010). According to a UNESCO report on the status of technological development in the Arab states, including Oman and the neighbouring Gulf countries, it was stated that "they paradoxically have no solid science and technology (S&T) base and their higher education systems perform poorly when it comes to generating knowledge" (UNESCO, 2010, p. 1). The economic significance of the oil and gas sector has driven inward technology transfer from various external sources, mostly located in developed countries.

The proposed conceptual framework of this study highlighted how a country's geographical location might influence its technological learning and catching-up (e.g. Ganesan *et al.*, 2005; Griffith *et al.*, 2009). For example, China has benefited technologically from a geographical and cultural proximity with South Korea (Kalvet and Kattel, 2006), and some European countries have benefitted from their proximity to the UK (Griffith *et al.*, 2009). Oman, on the other hand, does not benefit from its geographical proximity to neighbouring countries as the entire region is lagging in technological development.

Weak Omani internal technological capacity and its geographical location have made Oman rely on external sources for technologies to extract natural resources and develop indigenous technological capability. The literature review highlighted how the process of technological learning and/or capability development in technologically lagging countries goes through a technology transfer process from external sources (e.g. Kumar *et al.*, 1999; Viotti, 2002).

However, it is also highlighted that technological learning does not occur if the technology transfer process is not supported by indigenous activities of adaptation and internalisation (e.g. Lin, 2003; Zahra and George, 2002). One of the early steps taken by the Omani government to develop its indigenous capability was the reform and improvement of the national education system. Almost all development plans highlight education as a key driver of the country's socio-economic development. This is also emphasized in the country's long-term strategy (Oman 2020), which highlighted education as a route to desirable



sustainable development and economic growth. The national education system has been established and improved at various levels. The following section reviews the various internal efforts that Oman has made in an attempt to develop its national learning system to support inward technology transfer.

### **5.2.1 OMAN'S NATIONAL LEARNING SYSTEM**

The recognition of the Omani government that technological development and economic growth require an educated and skilled labour force has driven the development of the country's learning system (Ministry of Education, 2013; Ministry of Manpower, 2013). The literature review has highlighted that the development of the qualified national workforce through training and education is a key step in the development of a national learning system to support the inward technology transfer in developing countries. Oman has made substantial steps to improve its education system to develop its indigenous workforce.

Prior to 1970, there were only three schools in Oman that provided education to a very few fortunate members of the population in only two places across the country, Muscat in the north and Salalah in the south (Ministry of Information, 2013). After 1970, the government committed to improve the education system and accordingly the number of schools increased from three schools in 1970 to 1,529 by 2012 (NCSI-Oman, 2013); and the number is still increasing to meet the population growth. Oman has adopted an education strategy that offers equal access to education opportunities for all citizens so they can access free education at school and public universities or colleges. This is supported by a noticeable gradual increase in public expenditure on education as a percentage of GDP: this reached 4.5% in 2009, of which 29.9% went to tertiary education (The World Bank, 2013).

School level education lasts for 12 years, after which tertiary education starts. Based on the results scored in year 12 at the school level, a student may choose one of the opportunities provided in the higher education sector. These include learning at local universities and colleges, vocational colleges or institutes as well as getting local or overseas scholarships (Ministry of Higher Education, 2013).

To increase the opportunities for education and training, and to meet the growing demands of the local economy for qualified personnel, the country has invested hugely in developing the higher education sector in terms of number of universities, colleges and vocational institutes (Ministry of Higher Education, 2013). Today, although there is only one public university, namely Sultan Qaboos University (SQU), there are twenty-seven private universities and colleges, all focussing on preparing the national absorptive capacity in terms of qualified personnel (*ibid*). These universities and colleges offer different fields of study including engineering, science, business and management, medicine, agriculture, and art.

In addition, there are also seven public vocational technical colleges managed by the Ministry of Manpower. These colleges provide science and engineering related vocational training and education to prepare skilled and semi-skilled graduates to meet the local demands for a qualified national labour force in various vocational and technical areas (Ministry of Manpower, 2013).

However, despite the country's efforts to develop the national absorptive capacity through education and training, developing qualified personnel through education and training has been noted as only one element in the national learning system to support effective technology transfer (Viotti, 2002). Learning to master and localise foreign technologies in terms of adaptation and improvement requires, in addition to qualified personnel, engagement in R&D activities (Figueiredo, 2003; Viotti, 2002), something Oman has yet to achieve. This might be inferred from the low national expenditure in R&D as a percentage of GDP, the low number of scientists and researchers, as well as a weak R&D infrastructure such as research facilities (UNESCO, 2009).

For instance, in 2011 the national expenditure on R&D as a percentage of GDP was found to be only 0.13% in comparison to a neighbouring country that allocated 0.49% in the same year (The World Bank, 2011). Likewise, for the same year the number of researchers in R&D (per million people) in Oman was found to be only 160 (*ibid*). From the output side of the learning system, the total number of

scientific and journal articles that were published by local researchers in the same year were only 144 (*ibid*), which is very modest by the international standards.

Nonetheless, the experiences of countries that managed to catch up and develop an active learning system indicate that those countries have a private sector that is actively involved in the learning and the development of national absorptive capacity (Figueiredo, 2003; Viotti, 2002). The Omani learning system suffers not only from a weak R&D system but also from a modest participation of the private sector in the R&D activities (TRC, 2010). Almost none of the local firms possess an internal R&D department or hires dedicated scientists and researchers. There are also minimal contributions from the private sector on national R&D expenditure. Moreover, the university-industry linkages were found very weak or absent (*ibid*), which indicates lack of local knowledge transfer.

In general, the Omani national S&T system can be characterized by modest engagement and investment, low specialized or dedicated personnel, and weak infrastructure. Most S&T activities are within the public sector (universities and colleges), with minimal contributions from the private sector. The S&T system in general is a fragmented system at the development stage, where some of the elements of the system, such as universities and firms, are present but where most of the linkages and coordination among the different elements are absent.

The weak status of the Omani S&T system has been noted by international organizations such as UNESCO. UNESCO's country report on the Omani science and technology system concluded that "Oman has not yet hugely invested into R&D, nor do they possess the sufficient human resources to promote S&T for development. Hence, they have manifestly lagged behind some of their neighbours and of course the rapidly advancing Asian countries in terms of S&T input and output indicators" (UNESCO, 2009, p. 20).

Nonetheless, the practices of countries that have managed to develop their national learning system and catch up, such as the newly industrialized economies (NIE), suggest several lessons for countries like Oman. First, these countries have learned to catch-up by transferring and absorbing innovations from external sources and not just through internal R&D activities (Bell and Pavitt, 1993; Viotti,

2002). In that context, these countries did not start learning for the sake of innovation *per se* as much as they intended to learn about existing technologies and adapt them to the local contexts. Accordingly, the technology transfer process from external sources was significant for their learning and technological development. These countries have supported the technology transfer by enhancing their local education and training system to generate the skill pool of qualified workforce that will drive the technological learning.

Second, these countries have started the learning process and successfully accumulated a technological capability by focusing on sectors that are considered the main drivers for economic growth (Radošević, 1999). Such sectors require various types of technologies for their operations, thus driving inward technology transfer. This sector imports various foreign technologies and stimulates the demands of other sectors for foreign technologies through becoming a leader in the adoption of various technologies.

Third, as firms are the locus of technological development (Figueiredo, 2001), large domestic enterprises were noted to drive the indigenous technological learning process (Radošević, 1999; Viotti, 2002). Fourth, firms' learning from external sources has mainly become possible through direct interactions with the sources of external technologies (Capannelli, 2001; Cyhn, 2002). These firms have developed and dedicated the resources (qualified personnel) required to interact with the original sources of technologies so that the tacit and complex elements of foreign technologies can be acquired.

Within the Sultanate of Oman, the sector that drives the growth of the national economy and that stimulates local demands for external technologies is the oil and gas sector (PDO, 2013). Within the sector, Petroleum Development Oman (PDO) and the Omani Liquefied Natural Gas (OLNG) are the largest local enterprises in terms of human resources, capital and business. The oil and gas sector in general, and these two firms in particular drive the inward technology transfer to the country. However, since the two firms rely heavily on external technological sources for their operations, and because they are isolated from most technological sources, technology intermediaries play significant roles in the

inward transfer of external technologies for the sector. The following sections present an account of the sector in terms of its economic contributions, technological status and the two firms.

### **5.3 OIL AND GAS SECTOR: AN OVERVIEW**

The previous section recognized that the sector that drives economic development often drives and stimulates inward technology transfer, which in turn drives the national learning system. The Omani oil and gas sector dominates national economic revenue and generates 84% of the national income (NCSI-Oman, 2013). This high revenue drives the development of other economic sectors. The structure of the oil and gas sector includes the Ministry of Oil and Gas (MOG), plus several public and private companies working at different functions within the sectors including exploration, production, export and refinery (MOG, 2013). MOG is the government body that supervises and coordinates the development and implementation of government policy for exploiting oil and gas resources (*ibid*).

In order to develop the essential infrastructure to effectively manage the local oil and gas resources and the development of the sector through exploration, production and export, national firms have been established (MOG, 2013). The two major firms that have been established in the sector, which are largely owned by the government and that dominate the activities of the sector, are PDO and OLN, which were established in 1967 and 1994 respectively. These two firms were not only established to exploit or manage the national oil and gas resources, but also, importantly, to develop the local capabilities necessary to manage the sector, including managerial and technical capabilities (MOG, 2013; PDO, 2013).

The common element with these two firms is that they are both considered locally as leading and successful firms in the sector in terms of economic growth and capability development; this led to other firms adopting their experiences (PDO, 2013). The two firms are typical of large companies in terms of size of work force and capital, not only in the Omani context but also worldwide. However, they vary in several aspects such as the age, size in terms of number of operating sites, and the number of personnel involved in the business as well as the capital. In addition, the two firms differ in terms of the technological capability that has been

developed and accumulated. Accordingly, the level of technology transfer projects and technology intermediaries involved with the two firms vary as per the needs of the different firms.

By 2009, the total number of firms working in oil and gas exploration and production reached twenty two, operating in thirty two concession areas (MOG, 2013). However, these firms all relied to a large extent on external sources of technologies for their business operations. Nonetheless, some of these firms have engaged in various learning-related activities that aimed to localize foreign technologies and add value to external technologies through identifying new applications or adaptations (OPAL, 2012). In general, most firms have developed the technological capabilities necessary to operate and maintain the foreign technologies utilized in the sector (ibid).

However, according to Viotti (2002, 2003), firms that are involved in learning via inward technology transfer without internal R&D activities are viewed as passive learners that do not aim to improve the operation or performance of imported technologies, let alone produce alternatives. Although PDO is indirectly involved in local R&D activities, in addition to a few international firms that operate in the sector, most firms are not involved in R&D activities. This might explain the weak technological development in the sector in terms of improvement or innovation technological capability. Since firms are the locus of learning for innovation, the weak Omani national learning system might be explained by the lack of involvement of domestic firms in R&D activities to support learning from foreign technologies.

The following sections present the development of PDO and OLNG and their role in local learning and capability development.

### **5.3.1 PETROLEUM DEVELOPMENT OMAN (PDO)**

Following the exploration of oil and gas in the country, there was a pressing need to establish a national firm to manage the resources (MOG, 2013). Accordingly, the first national oil company was established in 1925 and was named Petroleum

Development of Oman and Dhofar; this was renamed Petroleum Development Oman (PDO) in 1967.

PDO is the foremost oil and gas exploration and production company in the Sultanate (PDO, 2013). It is the largest local enterprise and is majority owned by the Government who has a 60% share. Also involved in its ownership are Royal Dutch Shell at 34%, Total at 4% and Partex at 2% (*ibid*). PDO accounts for around 61% (2014) of the country's crude oil production and nearly all of its natural gas supply (*ibid*). It operates in a concession area of about 100,000 km<sup>2</sup> (almost a third of Oman's total land area), and has more than 126 production fields across the country and close to 6,000 producing wells (*ibid*).

To manage a business of this size, PDO developed its capability in terms of specialized workforce and technical infrastructure. It has a total workforce of over 8,000, both local and expatriates, where the latter are pulled in to play a role in the supply of national employees, as well as to contribute towards the development of the capability of the local workforce and knowledge transfer (PDO, 2013). PDO considers the development of the local workforce as one of its key strategic objectives; thus local Omanis are educated and trained through internal and external development education and training programmes from college and university leavers

The process of providing jobs to locals wherever possible is known as Omanisation. PDO tracks the development of technological and managerial skills in the local workforce through the growth in the percentage of the Omanisation at different positions of the company (PDO, 2013). Whereas expatriates dominated the workforce in the past, PDO has successfully managed to develop a local workforce that has gradually replaced expatriates (*ibid*). Today, the Omani workforce accounts for nearly 77% of the total workforce in PDO, and are qualified at different vocational and educational levels, with about 30% educated to bachelor degree level, 5% to Masters' degree level, but only 1% educated to PhD level. This workforce specializes in major fields of science, engineering, business, commerce, communication and public relations (*ibid*). They occupy different

positions at different hierarchical levels in the company, from the top management through to field operators and technicians.

The key objective of PDO is to “engage efficiently, responsibly and safely in the exploration, production, development, storage and transportation of hydrocarbons in the Sultanate” (PDO, 2013). In order to achieve that, and to enhance its overall performance, PDO employs the latest technologies and trains its staff to employ them efficiently (*ibid*). However, as PDO lacks or possess weak internal technology production capacity in terms of R&D capacity, it largely relies on external technological sources. It acquires external technologies either directly from their producers or thorough regional and local technology intermediaries.

Over the last decades, several technologies of different types, size and technical complexity have been transferred and deployed in PDO (PDO, 2009). These technologies include, but are not limited to, exploration and data acquisition and analysis tools, drilling rigs and pumping systems, process control systems, in addition to measurement and test technologies. As part of technology transfer, several capabilities have also been developed to support the utilization and exploitation of external technologies. The following section presents the technological development in PDO.

### **5.3.2 TECHNOLOGICAL CAPABILITY IN PDO**

PDO relies heavily on external sources of technologies that are geographically isolated . The development of internal technological capability to support inward technology transfer became crucial for PDO. It has been recognized that the development of firms' internal capability contributes to reduce its heavy reliance on external sources (Dahlman *et al.*, 1987): in addition it enhances the national learning system (Viotti, 2002). PDO considers the development of the capability of its employees through various education and training a significant strategic objective (PDO, 2013). According to various managers in PDO, technological capability in PDO is broadly perceived as the capability of individuals to manage, identify, acquire, operate and maintain technologies or techniques that might enhance the exploration, extraction and production of oil and gas resources.



PDO imports different technologies from various sources to manage its operations. The external technologies are transferred for different purposes such as the improvement of overall productivity, lowering production and operation costs, reducing the operation time, enhancing the safety of work, and reducing environmental impact (PDO, 2013).

Due to the lack of available published statistical data for the level of technological development in PDO, it was difficult to track firm-specific indicators for technological capability. For instance, although some PDO employees are involved in scientific publications for journals or conferences, PDO's management admitted that such activities are not recorded on a database. Moreover, several respondents highlighted that publication activities are not acknowledged in the annual appraisal reports, which does not encourage staff to effectively engage in such activities. In addition, due to its business sensitivity, the budget allocated for activities to publish or to attend conferences or workshops was difficult to discover during the fieldwork for this study.

PDO provides various training and education programmes, being inside or outside the country, on-the-job training, or long-term assignments in order to develop and enhance the capabilities of individuals. In mentioning the features in terms of personal development for employees joining PDO, PDO clearly states on its website:

*"PDO develops its employees throughout their career, through supporting further education, through participation in regular events like seminars and conferences, and through the company's e-learning, distance-learning and web-based network" (PDO, 2013).*

Local universities and colleges play a significant role in educating PDO personnel and other firms in the sector. Moreover, PDO offers its employees other professional training programmes, delivered either by PDO's internal qualified staff or by hiring external qualified training providers. To develop a skill pool of specialized local engineers, PDO has initiated customized training programmes that suit the specific needs of different departments. These are such as "The Engineers Monitored Professional Development Scheme" (EMPDS) or "Graduates

Development Program" (GDP) (PDO-2014) for supervisory positions, and "Technical Omanisation Program" (TOP) for operators and technicians (PDO, 2012). The different training programmes are customized to support the operation and maintenance requirements of different disciplines

As human resources development is a continuous process in PDO, and to cater for the growing demands of capability to support the growing business and managing inward technology transfer, PDO has established its own training centres across different operating sites. These facilities conduct hands-on training and demonstration of new techniques or technologies that have been imported to the company, as well as providing customized training programmes for new employees joining the company (PDO, 2012). Where PDO does not possess internal capability to train its employees on a particular aspect of its business, it seeks assistance from external expertise, including local or international trainers. Local training providers are often ex-employees of the oil and gas sector who have worked either in PDO or other firms within the sector.

In addition to internal and external training or education opportunities, PDO hires experienced personnel on a full-time basis. These are often industrial retirees who contribute towards the development of PDO's employees (PDO, 2013). These personnel are hired from different sources including other firms in the oil and gas industry or similar industries such as from manufacturing, the energy sector or even the construction industry. It was realized that such retirees carried rich experience directly related to oil and gas, or in areas close to oil and gas such as process plant operation, planning, project management, or even marketing.

An important approach for developing the competencies of individuals within PDO is the movement of the individuals between the different departments of the company (PDO, 2012). This allows individuals to learn about the various aspects of the business as well as interacting and learning from different expertise available across the company. This way of learning by interacting with other expertise is recognized by various respondents who highlighted that their learning from other colleagues within the firm is more valuable in developing their capability in comparison to other forms of learning.

One of the advanced personnel development opportunities employed in PDO for strengthening in-house talent, and that allows for knowledge transfer from external sources, is the “cross-posting” programme to one of the companies that belong to the Shell group (PDO, 2012). According to various respondents, this programme is designed mainly for experienced and qualified senior engineers and through which they are assigned to work with other international oil companies. This programme offers a valuable opportunity for local engineers to learn new skills through interacting and working with their counterparts in other companies that might possess different expertise, different technologies or techniques, or exposed to different operating conditions. Through such interactions with the expertise of other firms, local engineers get the opportunity to transfer different knowledge and experiences from external sources to local context.

Upon completion of the programme, those engineers contribute significantly towards the learning of others within the firms. They share their knowledge and experience with local employees through different means such as direct interaction, seminars and workshops. Several respondents in this study have been assigned to this programme and they now occupy senior positions in PDO, and are considered local experts in their field. Moreover, they were reported to enhance the learning of others about external technologies through explaining or simplifying external technologies to a level understood by local engineers.

As firms develop through the development of their staff (Mowery and Oxley, 1995), the various efforts of PDO to develop individuals’ capability have enhanced its capability to explore and exploit the potential of local natural resources and external technologies. For instance, PDO individuals were reported to be capable of interacting with suppliers of technologies, be it producers or intermediaries, and are in many cases capable of adapting external technologies for local operations (PDO, 2013). Such capabilities are of great importance for firms such as PDO that are distanced from the original technological sources and need to learn about the various options of technologies and further select the most suitable option (Radošević, 1999; Ramanathan, 2002).

However, while the development of learning capability of individuals significantly contributes to a firm's technological learning, learning also requires R&D effort as it progresses and advances (Dantas and Bell, 2009). PDO does not have an internal knowledge production capacity such as R&D facilities. Instead, it develops linkages with local universities to support addressing various challenges facing its business. For instance, it was reported by various respondents that PDO collaborates with Sultan Qaboos University and other private universities to solve some of its problems, or to gain advice and consultancy from expertise within universities. PDO considers this collaboration a tactic to access a wide range of expertise and new knowledge available at universities, and to develop technical capacity at the university by linking researchers and students with the industry in order to raise their awareness about the specific context and needs of the industry.

However, various respondents highlighted that external sources of knowledge, such as consultants, suppliers or even other users, play essential roles in facilitating their learning. In a situation such as PDO where most sources of technologies are distanced, local sources of knowledge, including technology intermediaries or universities, are expected to play an important role in supporting the inward technology transfer. Therefore, identifying a capable technology intermediary is a significant step in enhancing learning.

PDO keep a list of qualified suppliers who are eligible to provide products or services to PDO or its contractors (PDO, 2013). Those suppliers are, in some cases, not the original sources of the service or product but rather are technology intermediaries. Moreover, intermediaries are not all specialized in the oil and gas industry but serve wider sectors of the economy. While PDO's managers and engineers recognized the significant roles played by producers of technologies for their learning and firm's development, PDO learning from intermediaries is still not well articulated and it has not been subjected to scientific investigation. Whether the intermediaries enhance PDO learning still requires further investigation.

The above presentation about the process of developing PDO's internal capability (absorptive capacity) highlights that PDO makes several efforts to support the

inward technology transfer. This capacity is enhanced through investments in developing the learning capacity of individuals within PDO. Such capacity is not only necessary to enhance learning from external sources but also for the initial selection of the sources of external technologies, especially when sources are not the original producers. Moreover, that capacity has made PDO capable of adapting and customizing external technologies to the local context. Where such capacity is weak, local sources of knowledge are expected to play an essential role in supporting PDO's learning.

Having presented the status of S&T with PDO as the major operating oil firm, the following sections present a description of the second firm in the sector - OLNG.

### **5.3.3 OMAN LIQUEFIED NATURAL GAS (OLNG)**

Oman LNG was established in 1994 as a joint venture company between the government of Oman, with a total share of 51%, and international investors including Shell (30%), Total (5.54%), Partex (2%), Korea-LNG (5%), Mitsubishi (2.77%), and Itochu (0.92%) (OLNG, 2013). These international investors provide OLNG with finance for its projects, and with the skills and expertise required to manage the operation of the plant (*ibid*). The company engages in the business of producing and selling Liquefied Natural Gas and its by-products. In doing so, the company undertakes, directly or indirectly, project operations and related activities essential to liquefy, store, transport and market Oman's natural gas and to deliver LNG to customers. The activities of OLNG contribute to the Government's objective of diversifying the economy away from its current level of dependency on crude oil (*ibid*).

According to several of OLNG's managers, technological capability is perceived mainly in the ability of individuals to efficiently identify, operate and maintain technologies being transferred from external sources and to adapt them to the local operating environment. The development of capability of human resources is highly emphasized by the company. As stated in the company's annual report 2013:

*"We continue to emphasise training for all staff as a way of empowering our people to remain the best equipped in the oil and gas industry" (OLNG Annual report, 2013, p. 18).*

Oman LNG develops the internal workforce necessary to manage its business. However, the size of Oman LNG in terms of operating fields and number of staff is small compared with that of PDO. Oman LNG has a single operating site managed by a total workforce of 560 staff, of which 90.3% are Omani nationals (OLNG, 2013). This percentage shows the efforts of OLNG over recent years to develop the capabilities of the local workforce in managing the various functions of the plant. The local workforce has successfully replaced expatriates who used to occupy positions at various levels.

OLNG develops its workforce through various types of education and training opportunities to ensure their capabilities and competencies meet job requirements in the plant (OLNG, 2013). These opportunities vary from scholarships at local or external colleges and universities in addition to vocational training. In addition, Oman LNG offers customized vocational training opportunities for its employees to meet the specific and unique demands of the plant. This training is offered either internally through senior experienced engineers, or conducted by external training providers such as consultants or a member of its alliance. Human resource movement across different departments is also employed in OLNG as a way of within-firm knowledge and skills transfer from more to less skilled employees.

Similar to PDO, OLNG also transfers valuable external knowledge through the placement of senior engineers in advanced training programmes through the cross-posting scheme. In 2013, eleven members of Omani staff were on cross-posting programmes (OLNG, 2013). Prior to assigning them to work with international firms, those individuals have been exposed to various training and education to enhance their experience and skills so they are able to understand and contextualize to the local context what they learn from other firms. While this is always the case, there were some reported incidents where OLNG engineers were assigned to work with international firms (consultants) without having developed sufficient skills and experience (absorptive capacity) necessary to

support their interaction and learning from such expertise. The lack of such learning capacity prior to joining external expert teams was found to hinder knowledge transfer and learning from external sources.

One of the senior managers in OLNG shared his external assignment experience in working with one of the consultants who was hired to design parts of the plant, and highlighted how his lack of capability limited his potential to learn from those consultants. The manager said:

*"I was a fresh university graduate when I joined OLNG at its establishment time. Although I am an engineering graduate, I have almost no practical experience of the oil and gas industry. We were immediately given the opportunity to work with the international consultant -located in London- who is in charge of the major design tasks of the plant. As we didn't possess adequate industrial skills and knowledge, including poor language proficiency [spoken and technical] to communicate with the designers, as well as lacking specific technical knowledge required for the design, we didn't benefit greatly from that assignment, thus the level of knowledge transfer was modest. In general we didn't possess sufficient capacity to interact or participate in the design or even to engage in an intellectual conversation that contributes to the project. That gap in capability between consultants and us hinders the communication and learning during the assignment. Had we possessed skills and experience [language and technical] prior to the assignment we would have learned significantly from such an assignment"*

It is of no surprise that OLNG follow a similar approach for capability development to that of PDO as many employees, including members of the executive staff of OLNG, were ex-employees of PDO. While they moved from PDO to OLNG seeking better positions, those employees had accumulated rich industrial skills and expertise based on the PDO working environment. One of the managers in OLNG noted that, as the nature of business in PDO and OLNG is similar, the individuals from the two firms learn from the experiences of each other.

Like PDO, Oman LNG does not have an internal R&D department that might contribute to knowledge production. However, unlike PDO, Oman LNG does not

collaborate with local research institutes such as universities or colleges: the university-OLNG linkages are almost absent. According to a senior manager:

*"...To the best of my knowledge, over the last two decades Oman LNG approached Sultan Qaboos University only once and it hasn't approached other universities or colleges. We don't have lively collaborations with universities or research centres"*

The manager highlighted that specialized technical service providers, such as consultants or other firms in the industry, represent a significant source of technical support for OLNG.

The above section presented the efforts of capability development within OLNG to support learning from external technology transfer. The presentation highlighted that, while OLNG invest substantially in developing the capability of its individuals, it does not invest in R&D activities or establishing linkages with alternative sources of knowledge such as universities or research centres. Being isolated from original technological sources, together with weak or no linkages with local universities as a valuable source of knowledge, local technology intermediaries are expected to play a significant role in supporting the inward technology transfer and learning for OLNG.

#### **5.4 TECHNOLOGY INTERMEDIARIES IN THE OMANI OIL AND GAS SECTOR**

As presented above, Oman is an oil producer and oil-dependent country. Due to weak internal technology production, the Omani oil industry relies heavily on external sources of technology that are mostly located in developed countries. The weak Omani indigenous technological capability means that local firms might face difficulties in absorbing external technologies. However, local firms employ different means to support the inward technology transfer for learning and capability development. For instance, the fieldwork for this study found that some firms ally with other technologically sophisticated firms, establish linkages with local and foreign universities or research centres, send personnel for education



and training, attend technical workshops and gatherings, and, importantly, recruit retired experienced local and foreign engineers as consultants or advisors.

As a result of the constant needs of various support services in the oil and gas sector, there is a noticeable growth in the number of companies providing those services in the Omani oil sector (Khan, 2010). Among these are the technology intermediaries who support local firms through different functions to transfer technologies from their sources. This study identified that two leading types of intermediaries dominate most functions of technology transfer in the local oil and gas sector: these are consultants and agents (manufacturer representatives).

Almost all technology intermediaries in Oman are private entities that are owned by local citizens or foreigners. There is only one exception, the Omani Society for Petroleum Services (OPAL), which is a non-profit organization that offers different types of technical support to the oil and gas industry. OPAL advises, sets standards to the industry in compliance to international standards, and certificate providers for the sector. Local technology agents were found to constitute low numbers of personnel that often do not exceed ten at maximum. Moreover, local agents are, in most cases, owned by a single-family and largely driven by profit maximization. In contrast, consultants vary from being a one-man company as an ex-employee of the sector to a large international organization with hundreds of personnel, and offer consultancies in different areas to the industry.

As the two leading firms in the sector, PDO and OLNG keep lists of suppliers, including regional and local intermediaries, who provide them with different services and products. PDO and OLNG perform most of the tasks related to their business. However, due to the expansion in local business in terms of number of sites, the growth in the technology market (sources and options), in addition to a lack of certain skills and knowledge to identify technical problems or sources, both PDO and OLNG seek support from specialized service providers – intermediaries (OLNG, 2013; PDO, 2013).

Local intermediaries provide the oil and gas sector with a range of services, from simple catering and cleaning services through to engineering services, plant maintenance, oil well testing, in addition to training and education (OLNG, 2013;

PDO, 2013). Moreover, consultants in particular, such as OPAL and other consultants, are involved in setting standards for the industry, raising awareness about issues related to health, safety and the environment (HSE), offer training opportunities, in addition to supporting the accreditation and certification of Omani professionals (OPAL, 2014). Both PDO and OLNG adopted a policy to nurture the development of local service providers that support the operations of the sector. This policy aims to develop the capability of local intermediaries as well as to indigenize the service and products related to the industry (OPAL, 2012). Some of the tasks that PDO and OLNG outsource are directly associated with transferring technologies from external sources. For instance, both firms outsource the logistical tasks associated with importing technologies from abroad, such as identifying options of technologies and their sources, in addition to custom clearance upon the arrival of technologies to the country. Moreover, both firms seek the help of local intermediaries to access a wide range of sources of technologies that, without the support of those intermediaries, would have been difficult or impossible.

However, while intermediaries contribute to the provision of different services and products to the sector, their contribution towards the sector's learning remains not adequately understood. Although some intermediaries contribute to learning through training users in several aspects of the industry, not all of them are involved in such activities. Whether local intermediaries are capable of contributing to the sector's learning along the transfer process remains a point of investigation.

As was highlighted in the previous sections, firms in the Omani oil and gas sector do not possess internal knowledge production capacity such as R&D activities. In addition they are isolated from technological sources. This puts great emphasis on the suppliers (intermediaries) to support firms' learning along the transfer process, such as adapting and customizing external technologies or finding new applications for existing technologies. The role of intermediaries in supporting firms' learning is based on the notion that suppliers are assumed to support firms' learning along the various stages of the transfer process (Capannelli, 2001; Cyhn, 2002). In particular, the role of specialised suppliers in supporting learning in the

oil and gas sector has been established (Pavitt, 1984). Moreover, previous studies on inter-firm technology transfer and technological learning have highlighted the significance of identifying competent suppliers for effective technology transfer and learning (Capannelli, 2001; Cyhn, 2002). Such suppliers possess the capability to transfer technologies to a level understood by the recipients (Easterby-Smith *et al.*, 2008; Minbaeva, 2007).

In general, the Omani oil and gas sector, alongside the local technology intermediaries operating in the sector, have not been subjected to scientific enquiry in terms of their roles and functions along the transfer process, and what influences those functions. The boom in the local service companies (technology intermediaries) supporting the sector might involve low-quality and unprofessional companies that are not capable of supporting the learning of local firms. As technological learning requires competent suppliers to support the learning, understanding the functions of intermediaries and the factors influencing those functions, as direct suppliers, becomes significant for firms that are distanced from original sources of technologies.

## **5.5 SUMMARY**

Oman is an oil dependent country that is located away from most sources of technologies. Its technological learning system is largely based on absorbing technologies imported from external sources. The oil and gas sector is the primary sector that drives economic growth and foreign technology transfer. PDO and OLANG are the key players of the sector and the locus of the learning in the sector. Because the firms are distanced from most sources of technology, local suppliers (intermediaries) are expected to play a key role in supporting learning within firms in the sector. Whether intermediaries assume that role requires further investigation.

Having presented the background of the two cases, the next chapter presents the data collected from the two cases about their experiences on technology transfer through intermediaries.

## **6 CASE STUDY ANALYSIS: WITHIN-CASE REPORTS**

### ***6.1 BACKGROUND***

This study examines how technologies are transferred from producers to end-users through intermediaries, and how such transfer influences user's technological learning. This is implemented by examining the functions of intermediaries during the transfer process and the factors that influence those functions that, in turn, might influence learning, in a context where firms are geographically isolated from the original sources of technology. This study is based on the experiences of the two leading Omani firms in the oil and gas sector.

This chapter presents and analyses the empirical data gathered from the two firms, PDO and OLNK. The analysis seeks to discover what functions consultants and agents perform for the two firms along the transfer process, what factors influence their functions, and how those factors influence learning within the two firms.

The literature review of this study highlighted that effective technology transfer goes through a sequence of five stages, namely demand articulation, market scanning, acquisition, assimilation and innovation. While previous studies identified different functions of intermediaries for each stage (e.g. Howells, 2006), the factors that influence the different functions of different intermediaries along the transfer process remains not adequately explained. In other words, the factors that make different intermediaries perform certain functions on each stage have not been fully identified, thus remains difficult to identify which intermediaries perform what functions.

Based on insights from previous studies on technological learning and technology intermediaries, it is suggested that four interrelated factors might influence the different functions of intermediaries along the five stages. These are the proximity of intermediaries to users or producers of technologies, specialization of intermediaries, characteristics of technologies being transferred, and the capability of users of technologies.

In analysing the technology transfer experiences of PDO and OLANG through consultants and agents, this study systematically identifies functions of intermediaries along the transfer process and examines how the proposed four factors might influence the different functions of intermediaries. The study also looks for any emerging factors that might influence the functions of intermediaries along the transfer process.

The following sections present the empirical findings that are gathered through semi-structured interviews from respondents in the two firms.

## ***6.2 EMPIRICAL DATA ANALYSIS AND PRESENTATION***

The methodology chapter of this thesis explained and justified the adoption of a qualitative (interpretive) multiple case study as the appropriate research design for this study. This research was implemented by adopting the interpretive worldview and, consequently, the researcher attempted to understand the factors influencing the functions of intermediaries along the transfer process by interpreting the stories of technology transfer through intermediaries as described by different respondents from the two firms.

The presentation of the empirical data analysis follows Eisenhardt's (1989) suggestion that the data analysis of qualitative multiple case studies go through two levels. The first level analyses each case individually and presents the analysis in a within-case report. This analysis involves a detailed report of the findings of each case to allow the reader to become familiar with each case as a stand-alone entity. A within-case report is a descriptive analysis of the findings and does not involve a reflection of the findings on the findings of the previous studies.

The second level of analysis is a comparison of the findings from the multiple cases and presenting that in what is called cross-case analysis. While comparing the findings of the cases, the cross-case analysis also reflects the findings of the present cases with findings that have been obtained in previous studies. The within-case analysis allows the gaining of a deep understanding of the findings of each case individually, and allows the unique patterns of each case to emerge prior

to generalizing findings across cases (Eisenhardt, 1989; Miles and Huberman, 1994).

In order to gather more valid and reliable data, it has been decided to present the analysis of the two cases in a way that hides the identities of the firms and respondents as much as possible. In addition, to protect the anonymous nature of the report, which was an essential request from both firms, ALPHA and BETA will be used to refer to the two firms. Furthermore, it is suggested that the analysis of multiple cases adopts a unified template to analyse data of all cases (Miles and Huberman, 1994). The template in Table 6-1 is suggested for data analysis of the two firms in this study.

**Table 6-1: Within Case Report: A Template**

Points to cover in the "within case report"	<ul style="list-style-type: none"> <li>• Case ALPHA               <ul style="list-style-type: none"> <li>• Technology transfer process: the stages</li> <li>• Characteristics and function of consultants</li> <li>• Characteristics and function of agents</li> <li>• The influential factors on intermediary's functions along the stages of the transfer process</li> </ul> </li> <li>• Case summary</li> </ul>
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*Source:* developed by the author

## **6.3 CASE: ALPHA**

### **6.3.1 TECHNOLOGY TRANSFER PROCESS**

ALPHA transfers technologies from original sources, and it also works jointly with different local and regional technology intermediaries to transfer technologies. ALPHA follows a certain sequence to transfer technologies from external sources. The technology manager described the technology transfer process as follows:

*"...We [section heads] regularly conduct brainstorming or problem solving sessions during which we identify and define problems that each department faces. Moreover, during these sessions we also identify possible opportunities [articulate/stimulate demands] that might improve our operations. Once we agree on the problems, demands, specifications of the potential solution, we*

*look for the available options in the technology market that would meet our demands [market scanning]. The most appropriate option is then purchased, transferred and deployed. Throughout the process, we work together with our partners [suppliers/intermediaries] to identify the available options and their sources, the cost, specifications, and how they might help in addressing our needs."*

ALPHA's technology transfer process, as per the above description, involves four key stages from the five stages that have already been recognized and defined in the literature review (e.g. Bessant and Rush, 1995). These four stages are:

- Demand articulation: through different exercises such as brainstorming, problem solving, strategic planning, and discussion forums, ALPHA recognizes internal demands for external technologies by defining problems or identifying opportunities. This stage is based on reports from different sites on different challenges that face the operation or suggestions to improve the present operations. The outcome of this step leads to identifying and defining the problem, identifying the specifications of potential solutions, and recognizing potential opportunities that might enhance the operation.
- Market scanning: This stage identifies a range of options (solutions/opportunities) that might help to address the demands (challenges or opportunities). This stage also involves assessing and prioritizing the various options that are available in the market in order to select the most compatible option that is adaptable with the existing system and technologies.
- Acquisition: this stage is the actual transfer (import) of the options that have been selected or suggested in the previous stage. According to the manager, this stage involves communication with the sources of the options being selected, negotiation about the price and services provided including installation, training, transportation, intellectual rights and other logistics necessary to import the technologies.
- Diffusion and utilization (deployment): the final stage in the process is the utilization of the transferred technologies. This stage includes adapting

external technologies to the local system, and ensures the match between the external technologies and internal systems. Moreover, it involves training users in operating and maintaining the technologies, and ensuring that the overall system is not negatively impacted by the installation of the external technologies. Field engineers highlighted that this stage might introduce or require some changes to the existing system for adaptation purposes.

These four stages of technology transfer underline the sequences being followed by ALPHA to transfer technologies from external sources. It is clear that ALPHA's transfer process is triggered by recognizing internal demands for external technologies. This stage triggers the implementation of the subsequent three stages as explained above.

Several respondents have also revealed these stages in several examples of technology transfer. The following example of technology transfer illustrates the four stages as described by one of the senior electrical field engineers:

*"...Several sites have reported they face electrical faults where they have regular electric trips and shut down. The site engineers investigated the issue but were not capable of identifying the source(s) of the faults or what cause those constant electric trips. A discussion forum was conducted with our consultants [specialised] to better understand the problem, define it and specify the solutions that might address those trips. The field engineers, the consultants and the section head attended that forum. Through an exchange of ideas and thoughts together with site visits, we collaboratively managed to identify the source of the trips and precisely define the problem. It was easy for us after that to identify the different options available in the market that might help in rectifying the trips. Representatives of various producers helped us in learning about the different options and selecting the appropriate option that fit with our operating condition. Finally, the option was imported and installed, which eventually fixed the problem."*

The above process highlights not only the stages of the transfer process but also the actors involved at each stage of the process. Whereas consultants were



reported helpful at the problem definition stage, agents helped in identifying a range of options from various sources. Moreover, the description highlights that the transfer process was initiated by internal demands (occurrence of a problem) in a demand-pull approach for technology transfer, where the internal demands triggers the transfer of external technologies.

Although in the above experience of the technology transfer, field engineers were noticed knowledgeable about the nature of the problem, they lacked the capability to specify it or to identify its sources. Accordingly, they sought specific support from consultants whose contributions to the process were guided or led by the field engineers. The prior knowledge of engineers about the nature of the problem, although inadequate to define the problem, bridged the knowledge gap with consultants and helped specifying and defining their involvement. This put engineers in a position to interact with consultants and seek specific technical assistance in areas where they lacked internal knowledge. Field engineers noted that their prior knowledge about the problem put them in a position to influence the transfer process, specifically the assessment and adoption decision, and be more specific on the quality of support expected from intermediaries. The engineer also described consultants on that occasion as motivated to engage in the transfer process, and considered it as a learning opportunity from knowledgeable users.

However, ALPHA's technology transfer does not always follow the demand-pull approach. Several respondents highlighted the supply-push approach of technology transfer where the transfer process is triggered by external sources such as the suppliers or other users. In some cases, technology agents stimulated the demands of users for particular technologies even if the existing system did not face a problem. According to technology advisors and field engineers, in the technology-push cases external technologies are pushed to the firm without a real need. As one of the field engineers stated:

*"...We often learn about some computer programs we use from their suppliers (local agents). They continuously visit us marketing their products and persuade us to adopt those programs. We assess those programs to ensure*

*whether they contribute to our operation and whether they are compatible with the existing system."*

This transfer process highlights several aspects about agents and users. First, it shows that agents lack adequate knowledge about the user's demands and internal system thus they cannot ensure the compatibility of external technologies with internal systems. Consequently, users have to assess and check the adaptability. Second, due to agents' lack of knowledge about the internal system (industry specific knowledge) in terms of operating conditions and present systems, users do not immediately accept the technologies proposed by agents.

On the other hand, as users are distanced from technology productions, they lack sufficient information about external technologies. Consequently, the information imperfection between agents and local users about the technology market means that agents tend to diffuse technologies about which users have insufficient information. Respondents highlighted that technology agents take advantage of the information they have about the technology market and try to influence the assessment of technologies and adoption decision of the users. The lack of adequate information diffused about technologies, in turn, influenced the user's learning about the technologies being transferred.

A third approach of the technology transfer, as mentioned by several technology advisors, is when technology transfer is not initiated by either demand-pull or supply-push. Instead, demands are stimulated by learning about the successful experiences of other users in the industry. This can either be obtained when ALPHA's managers and engineers share experiences with personnel from other firms at technical gatherings or workshops, or when consultants share the successful experiences of different users elsewhere. According to a technology advisor:

*"...The process [technology transfer] is not necessarily initiated by the need to address problems. It is initiated to exploit opportunities. We learn about new technologies when we attend workshops or conferences or other forms of gathering with engineers from other firms. We share experiences and we learn about how different technologies have contributed or otherwise to other*

*users. We consider those technologies and we assess their suitability and advantages for our operations. Once advantages are approved they are transferred and utilised"*

While the above example highlights the involvement of local intermediaries in the technology transfer process within ALPHA, there are some occasions when there is a need for specialized intermediaries who possess specific skills where local intermediaries lack such skills. In particular, according to several field engineers, specialized consultants are called when there is a new technology introduced or there is a need to learn a new technique, which, in many cases, is beyond the expertise of local intermediaries. Likewise, specialized intermediaries are called in when there is a problem that is unique or new in its occurrence. In an interview with a section head, he said:

*"...We face operational challenges that in some cases require specialised knowledge or expertise, new techniques or technologies which are beyond our capability or the capability of local intermediaries. In such cases we call specialised consultants"*

One of the incidents where specialized consultants were invited was an explosion in one of the oil fields, which created operational and environmental damage and economic loss. Local experts were unable to contain the fire. Specialized consultants were asked to help put out the fire, during which they shared their knowledge with the local engineers and intermediaries (consultants). Local engineers interacted and worked side-by-side with specialized consultants, and acquired additional skills and knowledge and ultimately learned the technique. That experience was recorded (codified) and shared with people across the company, and could be shared with other users. Respondents highlighted that the presence of local consultants with the specialized intermediaries enabled the latter to play the role of interpreter, simplifying the new knowledge for local engineers, when the latter was unable to absorb it directly.

These examples for technology transfer processes within ALPHA highlighted the stages that are implemented for the transfer and the actors involved at each stage. Moreover, the examples also highlighted the different approaches that initiated the

transfer process. Since technology agents and consultants are directly involved in the transfer of external technologies to the local oil and gas sector, it is important to analyse the characteristics that might influence their functions along the transfer process. The characteristics are analysed as perceived and described by respondents from ALPHA.

### **6.3.2 CONSULTANTS**

According to several managers and team leaders in ALPHA, consultants are regularly involved with ALPHA in the four stages of the transfer process. Respondents described consultants by different characteristics that they believe make consultants a reliable source of knowledge for technical assistance.

Several respondents view consultants belong to the same industry as their clients. According to a team leader:

*"...Local consultants who work with ALPHA are mostly ex-employees of the industry. They have worked in the oil and gas industry whether with ALPHA or other firms, thus they became knowledgeable about different aspects of the industry. They share a common technical language, similar understanding about the industrial contexts with users; in addition they share a common knowledge base and competencies of the industry. "*

Another team leader said:

*"...Some of them [consultants] were our colleagues working with us but they quit to meet growing demands in the local technology transfer market"*

The above characteristics of consultants as highlighted by respondents, such as the sharing of a common knowledge base and common organizational or technical language, can be grouped under cognitive proximity-related elements. Respondents also mentioned the influence of the spatial closeness and the ease of communication and interactions. Local consultants are based in Oman, which, according to various respondents, offers easy access to their knowledge and expertise. Moreover, according to respondents, it gives local consultants the opportunity to follow changes in the industry and learn about the specific needs.

Accordingly they are able to provide their technical support. As a senior manager stated:

*"...They [local consultants] are just next door to our office or a call from us. They continuously follow the change in our system. They come and work alongside with our employees".*

Since consultants have worked in the industry for a long time, in some cases for over 20 years, they have accumulated a rich legacy of industry-specific knowledge (oil and gas industry) on different aspects related to the industry. For instance, consultants became knowledgeable about various techniques or technologies employed in the industry, as well as the possible contexts and applications for which those technologies could be employed. The industry-specific knowledge made consultants capable of analysing technological systems, troubleshoot and diagnose problems, and suggest ways of rectifying them. In addition, while they were working for the industry they had been exposed to various problems of the industry, which they have successfully learned how to address. Additionally, due to their past work experience in different locations in the industry, local consultants are known to be knowledgeable in adapting and customizing external technologies to local contexts, thus they are involved with users for the adaptation and customization of external technologies. A technology advisor said:

*"...They [consultants] are equipped with rich industry related knowledge and experience that made them qualified industry practitioners who helps in diagnosing system and advising on solutions to address challenges."*

Moreover, different respondents have intensively reported the various capabilities of consultants, as a result of their accumulated knowledge on the oil and gas industry. For instance, a section head revealed the view of various heads when said:

*"...Some of them [consultants] were involved in the design phase of the system, thus they know how to analyse it."*

*"...They are knowledgeable about various technologies and their specific applications in the local contexts."*

*"...He [referring to a particular consultant] is the mastermind of the plant [process plant]. He was a team leader in ALPHA when this plant was under construction. Soon after the plant was handed to ALPHA, he retired and was hired as a consultant in charge of supervising the development of young engineers for the plant."*

The above quotes revealed the influence of intermediaries' technical specialization in the oil and gas industry on accumulating a great depth of prior knowledge about the industry, thus becoming capable of performing various functions along the technology transfer.

Respondents also mentioned an important characteristic of consultants, which is their connection to different users in the industry. This connection is strengthened by the geographical closeness between local users and consultants, in addition to the cognitive proximity that is generated as a result of working in the industry. In describing local consultants, a senior manager noted that the majority of local consultants were members of the industry, and some of them occupied senior positions in different firms. Specifically those consultants who previously worked in ALPHA are strongly connected to other firms across the industry. This connection is strengthened by the position of ALPHA as the leading firm in the local industry. Other local firms in the sector are mostly contractors for ALPHA, or are managed by engineers who previously worked for ALPHA. This connection of consultants with different users in the industry also allows the sharing of experiences and problem solving among different users.

Different respondents emphasized this role of consultants in connecting different users as it allows sharing different experiences. According to a field supervisor:

*"...They [consultants] are not necessarily knowledgeable about all aspects of the industry but they encouraged learning between different users by offering the platform for learning-by-interactions and experience sharing"*

This connection (networking with different users) that consultants established while they were working in different firms allowed them to work between different users in the industry and share each other's experiences across users of

the industry. Moreover, due to their previous work in the industry, local consultants were said to possess organizational related knowledge such as the way things work or are done in the local industry, language and jargon, in addition to technologies and capabilities. For instance, a team leader highlighted:

*"...While we all speak English we have also developed our own communication language and jargon that dominates our daily communication, especially in the field. We give names for some technologies or components that actually differ from their original names [technical terminologies]. Those [consultants] who have worked in the industry are able to understand our language and are capable of learning about our demands and of communicating and articulating external knowledge in a way we can understand".*

In addition to their industrial experience, as a result of the close proximity between local consultants and users, consultants were reported to work closely with users to understand precisely their demands, even when users are not able to articulate the specific demands or define the specific problem. Moreover, engineers also reported that the close cognitive proximity of consultants with users allows consultants to simplify, interpret and diffuse external technologies to a level understood by different users in the industry through the use of a common language and jargons.

Respondents highlighted that, although consultants in general accumulate their knowledge and experience as a result of working in the oil and gas industry, they evolve over time and specialize in particular areas within the industry. This type is known as specialized consultants who offer technical support in specific areas and often support the transfer of unique or new technologies. At this point, respondents differentiated between three types of consultants in the industry. Two types possess practical knowledge (industrial consultants) while the third type is the university-based consultant. Most local consultants who support technology transfer are general consultants.

The main feature of local consultants as opposed to specialized consultants is that the former accumulate their knowledge and experience based on working in the local industry and with technologies that are already diffused and utilized by local

firms. Moreover, local consultants are also in close cognitive and geographical proximity with local users. This made them aware of various contexts of local operating conditions where external technologies will be employed. In addition, local consultants offer users an easy access to their support.

However, various respondents highlighted that the close proximity between local consultants and local industry locked-in the experiences of local consultants and hindered their capability to bring fresh or new knowledge or experiences to the industry. Accordingly, local consultants were believed to be more capable in supporting the transfer of technologies, adapting or improving, that were similar to existing technologies (already deployed) but less capable in supporting the transfer of technologies that vary from the existing – new technologies.

However, according to a section head, although local consultants were less knowledgeable about new technologies, they still possess significant learning capabilities to absorb new technologies from their suppliers. They could support the suppliers of the new technologies in learning about the local operating conditions. The section head said:

*“...Although new technologies perform new functions, their operation principles are mostly based on similar existing technologies. This made local consultants quick learners about new technologies”*

This shows how the accumulated knowledge from specialization in the industry enhances the capability of general industrial consultants, which in turn made them learn about technologies that were beyond their scope of expertise (specialization).

Moreover, the respondents highlighted that local industrial consultants were involved with users at an early stage of the transfer process – demand articulation. This involvement, according to a section head, was largely driven by ALPHA's recognition of the capability of local consultants as a credible and reliable source to give support at an early stage. Accordingly, when consultants suggested the transfer of particular external technologies, the suggestions were often based on



an understanding of the internal demands. Accordingly, consultants follow the demand-pull approach for external technology transfer.

In contrast to local consultants, specialized consultants offered their services on specific aspects of the industry. Although, in general, they are knowledgeable about the various aspects of the industry, they focus more on very specific technological domains or systems of the industry. For instance, field engineers noted that specialized consultants might focus on field control systems, seismic technologies, safety-related issues, or even in managing particular stages of the industry-related projects. Moreover, specialized consultants deal with different users within the industry on a larger scale (global), thus they had accessed and accumulated a wide and rich experience on very specific areas by learning from the applications of different users. According to a section head:

*"...This type [specialised consultants] brings new experience and knowledge on specific points of the industry".*

As a consequence of their specialized expertise, ALPHA sought the assistance of specialized consultants for the transfer of new technologies that differ from technologies already utilized and deployed. As noted by technology advisors and field engineers, in many cases new technologies required the development of special skills and customized training programmes. Moreover, new technologies might also involve some changes in the existing system for their adaptation, which required special experience and skills. These requirements made users rely on specialized consultants to support the development of special skills or to supervise the changes required to adopt the new technologies with the system. Nonetheless, specialized consultants were reported to lack knowledge on the specific local context where their expertise could contribute. According to a team leader:

*"...Although they are knowledgeable and expert in the field, they still lack the knowledge on our specific contexts of applications"*

The above observations about specialized consultants highlight that effective technology transfer from consultants requires not only knowledge about the technologies being transferred but, importantly, also knowledge about the

contexts of the applications. Field engineers suggested that lack of knowledge about specific local contexts with the specialized consultants hindered their ability to adapt external technologies to the specific local operating conditions.

As local industrial consultants are more expert on the local contexts, while specialized industrial consultants are more knowledgeable about specific and new technologies, respondents highlighted that the transfer of new technologies often involved collaboration between local and specialized industrial consultants so the two fields of expertise (local contexts and specific technologies) are combined. This combination of expertise leads to adapting external new technologies to local contexts. Moreover, through the local consultants, new technologies are simplified and interpreted to a level absorbed by local users. As reported by a technology advisor:

*"...The transfer of new technologies requires not only knowledge about the technologies but also knowledge about the specific context where technologies will be used. While specialised consultants are knowledgeable about the new technologies, local consultants are knowledgeable about the specific context, which is necessary for the adaptation. We [ALPHA] often involve the two consultants for the transfer of new technologies"*

Different from the above two types of industrial consultants are the university-based consultants. According to several managers, this type possesses a scientific-based knowledge about certain aspects of the industry. Due to the country's isolation from technological sources, university-based consultants are expected to play a key role in firms' learning. However, due to the weak university-industry collaborations, users found university consultants often lack the actual experience on the contexts of applications of their knowledge. There is a lack of channels that link them with the local industry, which will raise their awareness about the industrial specific needs. As a senior field engineer noted, although specialized consultants also lacked knowledge about the local contexts, they were knowledgeable about the practical or different applications of technologies and how they might influence the existing systems. University consultants are not the same. As the senior engineer said:

*"...We found learning from them [university consultants] is quite difficult. First, in many cases they provide their advice and consultancy without adequate links to specific contexts for our industrial needs. Second, they often employ a scientific language that not all of our engineers are capable of understanding. Most of them [university consultants] do not possess the capability to simplify or interpret scientific technical language to a level understood by different users in the industry".*

This observation highlighted how the lack of industry specific knowledge and the lack of common language (cognitive proximity) hinder learning from local universities. For instance, the lack of a common organizational language was viewed as an obstacle in the way of university-industry knowledge transfer. This obstacle is also amplified by the lack of internal R&D activities with ALPHA, which is crucial to developing ALPHA's absorptive capacity to absorb scientific knowledge from universities.

Therefore, based on the empirical data gathered from ALPHA on their perception about consultants, it is possible to highlight several points. First, consultants belong to the same industry as users, which reflects the specialization of consultants on the clients' industry and the proximity with users in the industry. Second, that specialization and proximity influence the different functions consultants perform along the transfer process. For example, due to the proximity between local users and local consultants the later were found to be more knowledgeable about specific contexts and adaption, while specialized consultants were knowledgeable about technologies but lacked context-specific knowledge. Third, consultants worked closely with clients for knowledge transfer, which offers direct interaction with users. This interaction is further enhanced by the close cognitive proximity between users and clients.

The differences between the three types of consultants are displayed in the following, Table 6-2:

**Table 6-2: The Key Characteristics of the Three Consultants**

Industrial consultants	University
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Local (general)	Specialized	Researchers
<ul style="list-style-type: none"> <li>• Knowledgeable about similar technologies to existing and about the local context</li> <li>• Close proximity (adaptation and communicating)</li> <li>• (Lock in) effect due to too close proximity</li> </ul>	<ul style="list-style-type: none"> <li>• Focus on certain areas of the industry</li> <li>• Valuable source for new technologies</li> <li>• Lack local context knowledge</li> </ul>	<ul style="list-style-type: none"> <li>• Knowledgeable about the scientific aspects of the industry</li> <li>• Lack knowledge on the practical applications and on the contextual adaptation</li> </ul>

Source: compiled and developed by the author

Having identified the main characteristics of the three main consultants involved in the technology transfer of the case study firms in the oil and gas industry in Oman, the next section analyses the characteristics of the second main intermediaries, the technology agents, as they are perceived by respondents in ALPHA.

### 6.3.3 TECHNOLOGY AGENTS (MANUFACTURER REPRESENTATIVE)

The second type of intermediary involved with ALPHA along the transfer process is the technology agent. Respondents view technology agents as private entities that represent different manufacturers of technologies or other regional and global agents. They can be specialized agents and consequently represent manufacturers of specific technological domains or a specific industry; in addition they can be general agents that represent manufactures of different domains or industries, and accordingly serve different sectors across the economy. According to the technology manager:

*"...These [agents] are offices that represent –locally- various regional and global suppliers"*

As they represent manufacturers of technologies, respondents highlighted that agents are connected with a wider network of regional and global technology producers or other agents. Consequently, they play a central function in enhancing the accessibility of local users to technologies from multiple sources that without this network the access of local users is limited. According to a technology advisors:

*"...They [agents] are better connected to network of regional or global suppliers or other agents. We contact them [agents] mainly to learn about and to gain access to various options for our technological demands"*

In addition to their knowledge about sources of technology, several respondents recognized that agents also possess knowledge about the legal system that governs the technology transfer process at their sources and at the recipient's side. Consequently, agents not only enhance the accessibility of local users to external sources but also enhance the accessibility of external suppliers to local users. They helped suppliers to identify users for their products. Moreover, agents were reported to develop a repository in which they store the continuous demands of different users, the sources of different technologies, cost and specifications of different technologies, and other related information. According to a technology manager, this repository saved users time in market scanning as agents could provide information about different options in a short time. In addition to linking users with various sources of options, agents in some cases were cited to negotiate the prices and contracts with the original sources on behalf of ALPHA. Consequently, agents carry out the contractual agreement between sources and recipients.

However, according to several respondents, most agents were rarely exposed to real work-experiences in the oil and gas industry. Therefore, they lacked the industry specific knowledge such as where technologies are best employed. Moreover, field engineers found agents rarely share with them a common knowledge or have a similar understanding about the industry, which in turn meant that agents lack the cognitive proximity with users. Moreover, local agents were found not to focus on specific technological domains or industry. They supplied different users in different sectors with different technologies. The lack of their focus on particular technological domain or industry has weakened their accumulated related knowledge on a particular domain or industry. As a section head noted:

*"...The majority of them [agents] had rarely worked in the industry [oil and gas]. Accordingly they lack awareness about the specific contexts and needs of*

*the industry. Although they generally knowledgeable about the types of technologies employed in the industry, they lack adequate knowledge about the different applications or how to adapt technologies to contexts of different users"*

The modest knowledge of agents about specific technologies of the industry, or specific contexts of an application, limited their value added on technologies being transferred. Accordingly, despite the substantial support of agents in identifying various options of technologies, they were noticed to be less supportive in the simplification of knowledge for local learning, adapting it to the needs of specific users, prioritizing or advising on the different applications of particular technologies. In addition, they also lack the diffusion capability, thus were described to not disseminate sufficient information about technologies, which in turn was reported to negatively influence the user's ability to assess the various options. A senior field supervisor commented:

*"...They [agents] identify and bring it [technology] to the site but they offer modest subsequent support. They rarely advise on how to adapt technologies to specific applications or suggest different uses of a technology"*

The lack of value added provided by agents along the technology transfer process, including external knowledge processing such as simplification or interpretation in addition to articulation and communication, meant that users were less likely to use agents to transfer technologies that have tacit or complex characteristics, which requires knowledge processing for their effective transfer. Importantly, the lack of adequate prior knowledge and diversity of skills about any technological domain has made it difficult for agents to absorb tacit or complex technologies from their sources so they can later transfer that to local users. Consequently, agents were intensively reported to be more suitable to transfer technologies that do not require intensive knowledge processing for its absorption. These technologies are such as computer software or hard tools. According to a technology advisor:

*"...They [agents] are mostly suitable to transfer technologies that often do not require sophisticated transfer capacity"*

Respondents highlighted the capability of local agents to support identifying sources of different technologies including complex technologies. However, the weak absorptive capacity of agents as a result of the lack of prior accumulated knowledge limited their ability to contribute in the actual transfer of those complex technologies. Their role in the transfer of such technologies was limited to identifying the sources, linking users with sources and carrying out the logistics associated with the actual transfer. They were rarely involved in the post-transfer stages, such as adaptation and training, when transferring such technologies. Although local agents are geographically located with users in the same country, the lack of industry specific experience has developed a communication gap (cognitive gap) between users and agents. For instance, a senior field engineer who deals directly with agents commented:

*"...They [agents] don't share with us a common understanding about the industry. The way we work differs from the way they [agents] work. Their knowledge about technologies is concentrated mostly about marketing while ours is mostly technical"*

According to this comment, the non-specialized agents belong to a different community of practice of users. They lack adequate industry-specific knowledge and they also lack sufficient knowledge about the technology they transfer. The difference in the community of practices creates a cognitive gap between agents and users.

It was noted that the lack of specialization of local agents on a particular industry or technological domain has weakened their accumulated related knowledge (absorptive capacity) about not only the industry but also about the external technologies. This in turn has weakened their capability to absorb and learn about external technologies, as well as their capability to disseminate and adapt external technologies to local users. It has been frequently mentioned that the lack of specialization of local agents on a particular industry negatively influences their technology diffusion capability. According to senior field engineers:

*"...As they [local agents] do not focus on specific industry or technological domain they fail to accumulate adequate knowledge about the industry or the*

*technologies being transferred. This has weakened their capability of diffusing technologies to individuals in the industry"*

In contrast to the non-specialized agents, respondents also highlighted the presence of some specialized agents who supply the oil and gas industry with particular technologies that might also be utilized by other sectors. For instance, in addition to supplying the oil and gas industry, some specialized agents supply measurement and test instruments that also are being used by different sectors such as manufacturing. This type of agent is found to be knowledgeable about their technological domain, but lack knowledge about the industrial contexts and applications. This lack of knowledge hinders their capability to adapt or customize their technologies to meet the specific needs of different users in different sectors. When agents transfer new technologies, users, jointly with local or specialized industrial consultants, perform the adaptation process of external technologies. Local and specialized industrial consultants offer support in simplifying and communicating the new technologies to the local contexts.

Since agents represent different manufacturers, they were recognized often adopting a technology-push approach for technology transfer. Agents persuade users to adopt particular technological options without sufficiently understanding or considering users' particular demands or contexts. As a result of their weak knowledge about the industry, agents were often not involved with users at the demand articulation stage. Accordingly they were not aware of the specific demands of users so they could not identify the technologies that would meet those demands. The lack of agent's knowledge about the industry and the context make them less capable of ensuring a match between the supply and the specific demands. Consequently, users only accept technologies that are promoted by agents if users are confident about the compatibility with local contexts. As technology advisors reported:

*"...Although they [agents] transfer several technologies for the industry, they rarely advise on the adaptation or the different applications of technologies. Their value added to the technology they transfer is modest"*



*"...We found them [agents] pushing for certain options. They represent manufacturers thus their role is to market and sell their [manufacturers] products without sufficiently considering the end-user specific context or needs"*

The above discussion highlights the main characteristics of agents, as respondents from ALPHA perceive them. The key characteristic of agents was found in their central connectivity to a wider network of technology suppliers. Through this network they enhance the accessibility of local users to a wider option of technologies and equally enhance the accessibility of suppliers to access local markets. On the other hands, agents were reported to be detached from users thus lack in most cases the cognitive proximity, which, in turn, hinders the transferability of external technologies.

#### **6.3.4 TECHNOLOGY INTERMEDIARIES: SUMMARY OF ALPHA**

The two sections above presented the description of the main characteristics of consultants and agents, as respondents from ALPHA perceive them. The description revealed that consultants belong to the same community of practice as their clients, while agents often do not. The prior work experience of consultants in the users' industry made them knowledgeable about various aspects of the industry; thus they share a similar understanding and knowledge of the industry, which was not found to be the same for agents.

Due to the recognition of the prior knowledge of industrial consultants, ALPHA considers them reliable and a credible source of knowledge. On the other hand, agents were found to be active in performing several key functions necessary to establish technology transfer projects such as identifying sources and linking users with sources. Moreover, they develop a database for the different technology requests. This database can be used for future requests for technologies. However, agents were described to be less involved in the post-transfer stages including adaptation or training users.

Moreover, field interviews identified that respondents differentiate between different categories of the same type of intermediary according to their closeness

to users and prior knowledge (proximity and specialisation). For instance, respondents classified consultants into three categories of general, specialized and university consultants. This categorization is largely based on the prior knowledge of consultants about the industry and the proximity to local users. Similarly, agents are categorized into general and specialized consultants based on their prior knowledge about technologies being transferred (specialisation).

In addition, interviews with ALPHA also revealed that technology transfer via consultants occurs mainly through the direct interaction between users and consultants; they thus offer greater opportunities for knowledge transfer and learning. In contrast, agents rarely offer direct interactions. Prior knowledge, together with the proximity of different intermediaries, meant that users expect each type to transfer technologies of different characteristics. For instance, whereas general industrial consultants were reported to transfer technologies of a tacit and complex nature, general agents were reported to transfer codified and simple technologies.

Having discussed the main characteristics of consultants and agents as perceived by ALPHA, the following sections present the different functions of both intermediaries along the four stages of the technology transfer process as described by ALPHA's technology managers. As mentioned earlier, the functions of consultants and agents are examined continually from the lenses of the four factors of proximity, specialization, technology and capability of users.

### **6.3.5 FUNCTIONS OF CONSULTANTS AND AGENTS ALONG THE TRANSFER PROCESS**

- **DEMAND ARTICULATION**

Demand articulation has two main functions. First, it aims to identify and define specifically any problems that face a particular department; thus technology transfer is driven by the need to address the problem. The second is to recognize any opportunities for external technologies that might enhance or improve the present operations.

As per the views of different respondents, problem definition involves analytical exercises through which problems are identified and defined specifically. According to a technology advisor:

*“...This stage requires a thorough knowledge about the analysed technological system in order to identify its faults through troubleshooting or tracing the roots of the faults. Moreover, it also requires knowledge about the technologies in the market that might enhance the operation of the system”*

The technology advisor noted that two types of knowledge are essential for the demand articulation. First is a thorough knowledge about the different elements of the technological system being analysed. This knowledge assists in understanding the abnormality of the system in order to identify its faults. In addition, this knowledge also assists in identifying new opportunities that might enhance the current performance of the system. The second knowledge is about the technology market through which a range of options might be identified. This knowledge assists in exploring technologies that might address the challenges or enhance the performance of the system.

Several respondents mentioned that local industrial consultants, due to their prior work experiences possess sufficient knowledge about the different technologies and systems that are employed in the local oil and gas industry. The industry-specific knowledge that is required at this stage enabled industrial consultants to become more involved with ALPHA in the problem definition than technology agents, who, as described earlier, do not possess adequate industry-specific knowledge. Local industrial consultants help to diagnose and analyse technological systems in order to identify the sources of the faults or problems. However, university-based consultants were cited to be less involved and provided minimal support at this stage. They offer minimal help in diagnosing technological systems as they lack the industry-specific practical experience of different technologies. Nonetheless, they provide more scientific analysis –research- and understanding of the nature of the problem, once the problem was identified.

Local industrial consultants not only help to define problems once they occur, they also articulate users' demands for potential opportunities when users are less capable of doing so themselves. According to one of ALPHA's managers, the function of articulating users' demands requires industrial knowledge and good communication between users and consultants so they can understand and

communicate the demands of each other clearly. This proximity made consultants capable of understanding the demands of users and further articulating those demands where users fail to do so.

The process of demand articulation was described involving direct consultant-user interactions. According to several team leaders, industrial consultants support ALPHA in the demand articulation stage by joining, when requested, the sessions of strategic planning, problem solving or brainstorming. They work closely with users, and help define the problem.

The empirical data also revealed that local industrial consultants also stimulate the users' demands for technologies or techniques that might enhance the performance of the existing system. Industry-specific and context-specific knowledge enhanced the role of consultants from simply being reactive to users' requests to being more proactive and stimulating users' demands for certain technologies or techniques.

The demand stimulation function of consultants is one form of a technology-push approach for technology transfer. However, respondents mentioned that consultants push for certain technologies by raising users' awareness about the potential of technologies or techniques that might be new to users, or might be already available to users but whose exploitation has been low. Moreover, consultants push for technologies based on their understanding of internal systems and its context. This technology-push approach differs from the agent's push approach since agents were cited to push for technologies with less knowledge about the users' demands.

The central position of local consultants within the industry (connections with different technology users) allowed them to share successful experiences of different users with each other. Accordingly, respondents reported that when consultants noticed a particular technology or technique had helped a user in the industry to address a problem or enhance an operation, they made other users aware of that technology or technique. Through this awareness, consultants stimulated the demands for that technology or technique. According to field supervisors:

*"...We have successfully avoided several problems based on prior suggestions of consultants to adopt certain technologies or techniques that we had not thought about. These [technologies or techniques] have been proved successful with other users operating in a similar context thus were suggested for our consideration"*

Nonetheless, despite the significant involvement of consultants at this stage, several respondents highlighted that ALPHA's engineers are heavily involved with consultants in the demand articulation process, and in fact they often lead the demand articulation stage. According to a section head:

*"...Yes, they [consultants] help us but we control the overall process. Their contributions are limited to areas where we really need external support"*

However, as cited by several respondents, the ability of engineers to lead the process of problem solving and demand articulation is determined by the possession of sufficient prior knowledge about the system being analysed or the problem being defined (absorptive capacity). Several engineers emphasized that when they lack knowledge and experience about a particular problem, consultants control the demand articulation stage. In such cases, some consultants were reported to make use of their knowledge power to influence the adoption decision for particular options of technologies. According to a section head:

*"...We noted some of them [consultants] make use of our lack of knowledge and thus they control the level of support they offer to us. They want us to continuously rely on them by screening the level of knowledge they diffuse to us. We avoid dealing with this type of consultant"*

This shows the consequences of the heavy reliance on intermediaries while lacking adequate internal knowledge, to an extent that intermediaries can use their agency power (knowledge) to influence the transfer process. This has a great impact for most users in developing countries that initially lack the capability to define problems or articulate demands and rely on external service providers – intermediaries.

Several engineers also cited that the functions of intermediaries at this stage were influenced by the characteristics of the system being analysed – the problem being defined. Respondents highlighted that the type of the problem being faced dictated the skills and knowledge of intermediaries. When the problem was new in a way that differed from the usual problems, a specialized industrial consultant with wider experience is invited. Due to the lock-in effect, local industrial consultants were less involved in identifying problems that were not regular to them or new in their occurrence. Since their experience was mostly gained from the local context, local consultants were reported to be less involved in bringing new and fresh knowledge to address emerging issues. Specialized consultants perform the problem definition and demand articulation for new technologies or techniques more than local consultants.

In contrast to consultants, local agents are less involved with users at the demand articulation stage. As highlighted previously, agents do not possess sufficient industry specific knowledge about the technologies or their contextual applications. Interviewees noted agents are generally less capable of analysing technological systems to identify its faults or improve its performance. However, agents involve themselves at this stage by stimulating the users' demands for certain technologies through a technology-push approach. As a local representative of different suppliers, agents are keen to diffuse their products or services to wider users, even when they lack sufficient knowledge about the user's specific contexts or demands.

The collaboration between different consultants and users throughout this stage leads to identifying and defining the problem, defining standards or the specifications of the external technologies or techniques that might solve the problem, and identifying future opportunities. The next stage is to search for the technological options that might contribute to meet the demands through scanning the technology markets.

- MARKET SCANNING

According to several interviewees, this stage aims to explore the technology market for available options, assess the suitability and compatibility of different

options within the local context, and finally prioritize and select the most appropriate options that meet the internal demands and match with the contexts. Both consultants and agents are reported to participate with ALPHA at this stage. However, they were described as performing different functions.

Since consultants actively participate in the demand articulation, they are also engaged in scanning the market for available options with a better understanding of the specifications and characteristics of the potential options that will meet the internal demands – solve the problem. Accordingly, it was reported that consultants often follow the demand-pull approach for market scanning in which external technologies are identified based on predefined specifications. According to a team leader:

*“...Their [consultants] engagement in the market scanning is guided by their engagement in the demand articulation”*

However, it was cited by several engineers that local industrial consultants were not seen as being embedded in a wider network of suppliers. Several engineers cited that consultants at this stage are not heavily involved in the actual scanning for external options as they were embedded in a limited network of suppliers. Instead, at this stage they perform other intellectual and supervisory functions based on their prior industrial knowledge and experience.

Respondents highlighted that consultants were directly involved in assessing the various options of technologies that were identified to users (scanned) by agents. As already highlighted, agents are less capable of assessing and prioritizing different options available for the needs of different users. Consultants perform the assessment process to inform the adoption decision of users. Local industrial consultants process technology related information through the simplification and interpretation of complex information, by using a common language, to a level understood by different recipients in order to suggest the most suitable option. According to a technology advisor:

*“...They [local consultants] interpret and simplify the information [technology related] to a level we can understand, putting us in a better position to decide on adopting the most appropriate option”*

Consultants also play a policing/quality check role in which they ensure options identified by agents are according to the specifications and characteristics that were defined in the first stage of demand articulation.

While consultants were less involved in the actual market scanning process in comparison to agents, they were reported to have developed a repository system for the identified options, the circumstances (conditions) for which they were employed, and all other information that might assist their clients in the future. The functions of consultants at this stage are enhanced by their prior knowledge about technologies (domain) being used in the industry in addition to their cognitive proximity to users. Their prior knowledge (absorptive capacity) has made them capable of absorbing information of external technologies and simplifying them to the local level. Equally, the cognitive proximity, including sharing a common language and knowledge base, has made them capable of interpreting, articulating and communicating external language to organizational language and jargon, which users of ALPHA can easily understand.

Agents, on the other hand, scan the market and identify a range of options. Engineers noted that agents are embedded within a wider network of regional and global suppliers. Consequently, agents enhance the accessibility of ALPHA to various options of technologies from which ALPHA can select. Moreover, agents were also described as recording the requests for technologies from different users in a database that can be accessed for future scanning process. Engineers found this database a time saving mechanism for options that are in continuous demand. However, several respondents highlighted the fact that agents made use of their access to wider networks and monopolized the information gained from that network. They controlled the level of information diffused to local users in order to protect their market position as a supplier.

Agents are involved at the scanning stage in both a reactive and pro-active approach. They participate reactively when ALPHA requests the support of agents



to identify options that are already specified in the demand articulation stage. That request often precisely defines the characteristics and specifications of the technologies or techniques to address a particular problem or meet a specific demand. Accordingly, agents scan the market within which they are embedded based on guidance provided by users. In addition, agents also behave proactively, or employ a technology-push approach, when they stimulate demands of users to adopt a particular option. Engineers noticed that agents push for technologies without sufficient knowledge of the specific contexts for the subsequent adaptation of technologies being pushed for adoption.

Interviewees reported that, as local agents possess only a modest technical understanding of technologies they transfer or the contexts of applications, they were reported to be less involved in assessing the various options in a way that helped ALPHA to adopt a particular option. Instead, agents provided a list of options that might meet the internal demands based on the specifications previously defined by ALPHA. Moreover, it was also cited that agents add less value to the information they provide in terms of information processing; this included simplifying or interpreting technology related information so engineers could understand and become well informed for the adoption decision.

Since information plays a key role in the assessment of options for the adoption decision, respondents highlighted different behaviours of intermediaries at this stage with regards to the provision and processing of information. First, agents were noted to rarely provide sufficient information about the different options they market or they intend to transfer. Field engineers highlighted that agents often provided information that came in the manuals and catalogues, which are often provided by original producers to market the products. According to field engineers:

*"...That information [manuals] is not always sufficient to assess different options of technologies in order to make the adoption decision"*

Respondents largely attribute the lack of sufficient information diffused by agents to two main reasons. It could be due to the modest capacity of agents to absorb information from original sources then diffuse to local users. Agent's personnel

were reported to possess modest technical capacity to absorb tacit or complex technologies from producers. They were described more as marketing-oriented than they are technical personnel. Therefore, they often transfer technologies without transferring adequate associated knowledge. Second, engineers also highlighted that, in many cases, agents are reluctant to diffuse sufficient information even when they have it. According to different engineers and technology advisors, the fear of losing a market position as a main supplier makes agents reluctant to provide users with sufficient information, thus they control the level of information.

However, there are some specialized agents in the local market that supply particular services or products. Specialized agents were noted as being capable of supporting users in the assessment process of various options. They simplify and interpret information of technologies that fall within their speciality. However, as reported previously, specialized agents do not possess adequate knowledge about the specific contexts of applications, thus they were less capable of advising on a particular option that is compatible with an internal system. Instead they facilitated the user's absorption of information about technologies, and then the users decided on which option to adopt. This highlights that the knowledge about one side of the transfer (user side or market side) does not help for effective assessment. As highlighted, technologies are assessed on their operability and their compatibility to the specific contexts.

Nonetheless, respondents highlighted two factors that might influence the information diffusion of intermediaries at this stage. One of these factors is the technical characteristic of technologies being transferred, including tacitness, complexity and novelty. The second factor is the prior knowledge of users about technologies being transferred.

According to several interviewees, agents in many cases are less capable of diffusing complex information about technologies. Such complex information is that which is linked to several technical fields and that requires a spectrum of skills for its diffusion. In addition, agents were also found to be less effective in diffusing information that is tacit (difficulty to understand) and that requires

direct interactions for its diffusion. This is mainly due to the weak absorptive capacity of agent's personnel. When technologies required are novel and differ from those already deployed with users, it requires intermediaries that are specialized in the domain of those technologies. Local intermediaries (consultants and agents) were both reported to be less involved in the scanning or assessment process of new technologies.

Equally, the prior knowledge of users influences the diffusion functions. Respondents highlighted that when intermediaries recognize that users are knowledgeable about technologies being scanned, they are more motivated to diffuse and share information about technologies. Users with prior knowledge are active participants with intermediaries in the way they demand specific information from intermediaries, which makes the latter diffuse the information that meets the specific demand. Moreover, users with prior knowledge are also able to monitor the quality of functions performed by intermediaries.

Similar to agency power utilized by intermediaries in controlling the level of information diffused, knowledgeable users at this stage utilize the negotiation power. When knowledgeable users seek services or products from intermediaries, they are in a strong position to negotiate the quality of service or products delivered by intermediaries. In other words, knowledgeable users are selective in the type and quality of functions performed by intermediaries. A technology advisor highlights this when said:

*"...When our engineers are knowledgeable about the technological options being identified, they are in a better position to influence the level of information diffused by intermediaries as well as also influencing the adoption decision. In contrast, when engineers do not possess adequate knowledge, or technologies being identified are new, then intermediaries fully control the diffusion process and in some cases they influence the adoption decision in favour of particular options".*

The above discussion highlights that the ultimate product of this stage is the adoption decision on a particular option that is compatible with the internal

system. This option is then acquired (imported) as discussed in the following section.

- ACQUISITION

The third step in the technology transfer process with ALPHA is the actual transfer of the options that have been selected during the second stage – market scanning. As stated by several respondents, the functions of intermediaries at this stage vary according to the characteristics of the technology being transferred. For instance, because of their weak absorptive capacity, local agents were reported to be mainly involved in the acquisition of technologies that are largely codified, such as computer software, oil pipes, chimneys or machines and tools that difficult to learn about. Although software, for instance, requires a certain level of absorptive capacity, respondents highlighted that such technologies can often be learned through the instructions or procedures provided in their manuals.

In general, at this stage, agents mainly perform functions of a physical nature while consultants perform more intellectual functions. Agents' functions include communication and negotiation with producers, linking users with different sources, negotiating the cost and establish the purchasing agreement, ensuring customs clearance to ensure the import of external technologies, and transporting the technology to where it will be finally installed in the field.

As agents are geographically isolated from most producers of technologies, the acquisition of technologies from their sources is reported involving minimal direct interactions with original suppliers. Consequently, respondents suggest technologies are transferred as a codified element. The lack of interactions is thought hinder the ability of agents to transfer tacit or complex technologies that were recognized as requiring direct interactions with their sources.

Industrial consultants, on the other hand, perform several significant functions for ALPHA to ensure the accomplishment of an effective transfer that includes physical technologies and associated knowledge. While they are less engaged in the physical transfer of technologies from external sources, they supervise the transfer that is implemented by agents. Several respondents highlighted that consultants at this stage perform a policing or supervision function. They ensure

technologies being acquired are as per the predefined specifications and characteristics. In addition, they ensure the transfer of knowledge associated with technologies, and that the intellectual rights are also transferred and absorbed by recipients. According to field supervisors:

*"...They [consultants] supervise the overall transfer process and ensure an effective transfer is implemented and specifications are met. They also assist in understanding [absorbing] technical knowledge of technologies"*

Respondents also noted that when technology being transferred is complex and constitutes different functions that require multiple kinds of skills or expertise for its transfer, consultants play a major role in supporting users for the actual transfer. Several field engineers highlighted that, due to the contextual nature of operations in the oil and gas industry, the operating environment varied from one site to another. Therefore, a technology that is successfully transferred and utilized in one field might not be successful in another. According to a manager in ALPHA:

*"...Most technologies in the oil and gas sector constitute multiple functions and draw upon diverse fields of skills and expertise, from data gathering for exploration purposes through to the downstream industry. Especially now, firms in the sector tend to employ smart technologies to monitor the different operation parameters of the fields in a continuous fashion. Some examples of these technologies are the SCADA system, digital hydraulic control valves and the distributed temperature sensing. Smart technologies track different functions in the plants such as the weather, fluid flow, pressure, electricity, the pumping system, and report on different behaviours of the field. As all these functions are combined in a single system, the complexity, tacitness and novelty of the system have increased"*

Technologies influence the functions of intermediaries by determining the characteristics of intermediaries that can transfer a certain type of technology. The transfer of complex or new technologies, from demand articulation through to adaptation, requires advanced diverse skills and expertise from the intermediaries involved. Local industrial consultants simplify and interpret the complex technologies to users as well as ensuring the adaptability of complex technologies

with an existing system. However, when the technology being transferred differs from the existing, or new functions are introduced, specialized consultants in the domain of the technology are more capable for the transfer process.

After the technology is transferred and installed, the next stage is the effective utilization.

- DIFFUSION AND UTILIZATION

The last stage of technology transfer with ALPHA is the diffusion and effective utilization of technologies being transferred. The ultimate goal of this stage is to put the technologies being transferred into operation and to train users for effective utilization. More specifically, this stage aims to ensure the transferred technologies meet the purposes for which they were originally imported (typically addressing problem or meeting opportunities).

This stage involves different activities such as the installation of the technologies in the field, adapting them to local conditions, integrating technologies into existing systems, training users into operating and maintaining technologies, and learning about the different possible functions of the transferred technologies. Moreover, the adaptation of new technologies in the existing system might introduce changes and modifications to the old system. By achieving these tasks, ALPHA considers the technology transfer successful. According to a technology advisor:

*"...The process [technology transfer] is considered complete and successful when the technology being transferred is working and performing the functions it was originally imported for".*

As this stage mainly involves adapting external technologies to an internal system, respondents highlighted that intermediaries involved at this stage were knowledgeable about the technology being transferred and the context of applications. While industrial consultants help users in adapting external technologies into the system and support users in learning about the technologies by absorbing its knowledge and assimilating it into the existing system,

manufacturer representatives (agents) perform mostly the physical installation of technologies.

Respondents reported that consultants were involved in adapting external technologies to the specific context and integrating them into the internal system. Moreover, consultants train users into the various possible utilization and applications of transferred technologies. In contrast, as local agents lack the industrial knowledge, they were noticed to be less involved in supporting users to adapt the transferred technologies. Although specialized agents are knowledgeable about technologies being transferred, they were often noted to leave the task of adaptation to end-users. Due to the lack of a common language, agents are generally less effective in simplifying knowledge to a level understood by different recipients. As a field engineer stated:

*"...They [agents] are less capable of supporting us in the post-delivery stage [adaptation and exploitation]. They lack the knowledge about the specific context where it [technology] will be installed"*

However, when the technology being transferred is new, specialized consultants were invited to supervise the installation and adaptation. Senior knowledgeable engineers from ALPHA worked closely with the specialized consultants in order to ensure the absorption and understanding of the new knowledge. For instance, according to field engineers, the adaptation of a new field monitoring system or new drilling mechanisms in some cases requires full integration between the various elements of the system, which requires multiple skills. In such cases, local industrial consultants facilitate the communication between specialized consultants and local users. Local consultants simplify and interpret the new knowledge and ensure the user's absorption of the system.

In addition, an important step in learning at this stage, as noted by field engineers, is learning about system troubleshooting after it is being in operation. Consultants share with users the analytical skills that help in analysing the system and conducting regular maintenance of the system.

There is a significant role for university consultants at this stage. They provide customized training (mainly theoretical courses) to educate users about various aspects of different technologies, including new technologies. However, the modules of these courses are often specified either by ALPHA or by the consultants and presented by university consultants. Users defined the potential areas for training to university consultants.

It was clear from various respondents in ALPHA that technological learning along the transfer process in general is limited to operational, maintenance, and adaptation of external technologies. Learning for innovation, such as improving the functionality of existing technologies to perform different functions or producing alternative technologies, is not recognized as a standalone strategic objective for technology transfer in ALPHA. According to one of the corporate managers:

*"...Technology strategy of ALPHA does not emphasise learning for innovation as a standalone strategic goal to achieve over the technology transfer"*

Accordingly, the resources allocated for the transfer process such as the selection of suppliers, the training provided for individuals involved in the transfer process and other supportive tools, are influenced by ALPHA's strategic commitments. According to the managers:

*"...We lack the strategic commitment to learning [innovation]. The ultimate goal of our learning is to use technologies for the purposes they were imported for. In general it is [technology transfer] mainly aimed to exploit more resources in an effective and efficient manner through increasing production, reducing cost, or enhancing safety".*

As technological learning requires a competent supplier to support the absorption and diffusion of external technologies, the lack of strategic commitment to advanced technological learning is thought by some respondents to make firms accept low performing or less-competent intermediaries. It was noted that intermediaries develop competencies in response to demands of users in terms of training and learning along the transfer process. As ALPHA selects suppliers for technology transfer through a tendering process, some interviewees believe



setting competency criteria for intermediaries who are eligible for the transfer would drive the competency development of intermediaries, making them more engaged in user's learning along the transfer process. According to a technology manager:

*"...When the aim of the company [ALPHA] is to develop advanced technological capability for innovation, it selects competent suppliers who can support achieving this objective. We have noticed that the aim of the company drives the development of capability of local suppliers in order to meet the demands of ALPHA"*

Respondents suggest that the firms' technology strategy can drive the development of competency of local intermediaries, if the strategy emphasizes learning as a strategic objective. In order to achieve that objective, a competent supplier will be selected for the transfer project. In contrast, when the objective of the transfer is limited to operating and maintaining technologies, intermediaries develop competencies to meet that objective. This lack of strategic commitment from ALPHA, according to several respondents, is among the key reasons why most local intermediaries are not keen to develop competencies to advance local technological learning. Moreover, the lack of the strategic commitment to learning has also negatively influenced the learning culture within ALPHA.

For instance, one of the highlighted signs that show the lack of ALPHA's strategic commitment to advance technological learning is the absence of a department concerned with the intellectual rights that make individuals aware about the significance of their learning and how they can develop their ideas. In addition, despite the fact that there are multiple individuals in ALPHA who publish in international journals or conferences, these activities are not recorded, nor are they recognized in the annual promotions. This organizational culture limits the involvement of ALPHA's personnel in scientific publications. According to one of the directors:

*"...Such activities [publications] are not highly acknowledged by the company. Publication in the sector is not linked to job promotion. That is why not many*

*of the employees focus on such activities, which in turn limits the innovative activities in the company”*

Respondents also believe that the technology strategy does not only influence the allocation of resources and motivation for internal learning, but it also drives the development of suppliers in terms of technological upgrading. Respondents underline that one way through which technology strategy can drive the development of the capability of intermediaries to perform more functions along the transfer process is by introducing a set of quality control measures for intermediaries who might be eligible to supply certain products or services. Through these sets of measures, user firms drive competition among the different intermediaries to meet those measures.

For instance, the transfer of some technologies, such as a complex field monitoring system, requires intermediaries with experience in such systems in order to be able to simplify the complexity of such systems to different users. As a result, local consultants compete among themselves to ensure that their abilities meet the technical requirements of the system being transferred. In contrast, due to the modest capability of most local technology agents, they are exempted from transferring such systems. Likewise, when the transfer process involves the transfer of new technologies, specialized consultants compete with each other to win the transfer project.

#### **6.3.6 CASE SUMMARY: ALPHA**

The above analysis of empirical data gathered about ALPHA's experience of technology transfer through consultants and agents identified that transfer and learning is a complex process and requires different knowledge and skills. The analysis highlighted how the four factors of proximity, specialization, characteristics of technology and capability of users all influence the different functions of intermediaries – agents and consultants.

In addition to these four factors, a new factor has emerged and that influences the functions of intermediaries along the transfer process: the corporate technology strategy. Corporate technology strategy can influence intermediaries' functions by

encouraging the development of intermediaries' technological capability. Several interviewees suggested that corporate technology strategy might act as a market regulator to ensure the quality and capability of intermediaries involved with users during technology transfer. This regulatory function of the strategy might be implemented by introducing a set of technical criteria on intermediaries willing to bid for any technology transfer project. To validate the influences of the strategy on the firm's learning and intermediaries' capability development – as a new factor, this will be emphasized when interviewing participants from BETA.

The set of five factors were found not only to influence the functions of intermediaries along the process, but also to create a division of labour among the same type of intermediaries. For instance, these factors differentiate the functions of industrial consultants from university consultants, with each type performing functions that the other type was less capable of performing.

Moreover, the analysis showed that intermediaries who might be capable of supporting effective transfer and learning were knowledgeable about external technologies and the internal context of use. These two types of knowledge are gained as a result of the proximity with technology markets and local industry. The analysis of the empirical data showed that consultants are closer to industry in comparison to agents who are closer to technology markets. Accordingly, effective technology transfer requires a mechanism of coordination that integrates the functions of both types of intermediaries. Furthermore, the analysis revealed that users select intermediaries based on their prior knowledge and proximity. For instance, university consultants are involved with users only in problem definition while industrial consultants are involved across all stages. The analysis also illustrated how the capability (knowledge) of users influences the functions of intermediaries along the process. Where users are not knowledgeable, intermediaries were found to practice agency power.

The findings from ALPHA redefined how technology transfer through intermediaries is different from technology transfer through original producers. It was found that technology transfer through intermediaries is a multiple process of transfer and that intermediaries play dual roles of recipients and suppliers. When

transferring technologies from their sources, intermediaries are recipients and thus should possess absorptive capacity to support effective transfer. On the other hand, when diffusing technologies to local users intermediaries are direct suppliers and thus should possess transfer capacity to support effective diffusion. The findings show that consultants withstand the dual roles while agents are less capable.

Having analysed the data gathered from ALPHA, the following section presents and analyses the experience of the technology transfer process through intermediaries with BETA.

## **6.4 CASE: BETA**

### **6.4.1 TECHNOLOGY TRANSFER PROCESS**

BETA, like ALPHA, is largely a state-owned company and a leading firm in the Omani oil and gas industry. BETA relies heavily on technologies from external sources, which are acquired either directly from producers or through local and regional intermediaries. BETA follows a sequence to transfer technologies from external sources. One of the senior managers involved in various technology transfer projects described the process as follows:

*"...Field engineers continuously record and report any problems in the plant to their supervisors. They also suggest new ideas for consideration, which might improve the performance of the plant. Each department conducts meetings to identify and get to know the problems facing the plant or the opportunities that might improve its different functionalities. Once they define the problems or identify the opportunities the search process for the solutions starts and continues until the solutions are deployed and utilised"*

It is not surprising that BETA's technology transfer process follows mostly the same steps as found in ALPHA's process. This is possibly due to the fact that key employees of BETA are ex-employees of ALPHA, including members from the executive management. When those employees moved to BETA, they carried rich skills and experience, including the management of technology transfer projects. Nonetheless, the transfer process as described by the manager will be organized

according to the same stages that were used for analysing the process of ALPHA, and as described by the manager of BETA. These are:

- Demand articulation: through open discussions or strategic planning sessions between different section heads, BETA defines technical problems that face the plant and identifies opportunities that might be exploited to enhance the performance of the plant. This stage leads to a precise definition of the problem or opportunities.
- Market scanning: through different local, regional or global suppliers, BETA explores technology markets to identify available options of technologies that might solve a problem or enhance performance. The different options are then assessed and prioritized in order to select the most appropriate and compatible options. The key outcome of this stage is the adoption decision for a particular option.
- Acquisition: this stage focuses on the physical transfer (import) of the options that have been selected for adoption. The process of acquisition involves different tasks such as communication with the sources, negotiation around the process and technical services including training, transportation and other logistics necessary to import technologies. This stage leads to the actual transfer of external technologies to the country.
- Diffusion and utilization: the final stage in the process, which is the installation and utilization of the transferred technologies. This stage is noted to include the adaptation of external technologies to be compatible with the plant and ensure the match between the external technologies and internal systems. Moreover, in some cases it also involves training users in operating and maintaining the technologies and ensuring the overall system is not negatively impacted by the installation of the external technologies.

However, managers highlighted that some technologies are transferred without following the above stages, such as when their partners from the strategic alliance suggest the adoption of a particular technology. The manager highlighted that their partners, based on their international experiences in the industry, stimulate BETA's demands for certain technologies and recommend the adoption. According to the manager:

*"...Although the demands for technologies are often identified internally, some technologies are transferred based on a suggestion from our partners. They have plants in different sites across the world and based on their experiences they recommend the replacement of an existing technology with a new one"*

Similar to ALPHA, the four stages of technology transfer are not all implemented by BETA. Local technical service providers such as consultants and agents play key roles with BETA for the technology transfer process. In addition to the significant roles of local consultants and agents, international partners of the alliance are another major player with BETA for technology transfer from external sources.

As the study focuses mainly on examining the functions of the two dominant intermediaries, consultants and agents, along the transfer process, and in identifying the factors influencing their functions, the following section analyses the characteristics of consultants and agents that might influence their functions along the transfer process. The following descriptions are as perceived by respondents from BETA.

#### **6.4.2 CONSULTANTS**

Respondents from BETA perceive that local consultants are often previous employees of the oil and gas industry. They have worked for the industry through which they accumulated industry specific knowledge and experience as well as developing organizational elements such as language and culture. The industry specific knowledge of consultants was developed and accumulated as a result of the closeness and specialization in the industry. In addition to sharing organizational elements, industrial knowledge puts consultants in proximity to users. According to a team leader:

*"...We know them [consultants] as colleagues. They used to work in different firms of the industry. They are known by all"*

*"...They [consultants] would not be able to offer their services to this industry [oil and gas] had not they accumulated industry specific knowledge about various technologies and applications of the industry"*

Respondents agreed that the work experience of consultants made them knowledgeable about the different aspects of the industry. Being connected to different users, industrial consultants were noted to facilitate the sharing of experiences and problem solving between different users in the industry. Moreover, local industrial consultants developed a learning platform that makes different users contribute towards the spread of knowledge and encourage learning among each other. According to a section head:

*"...They [local consultants] organise gatherings [discussion forums] and invite users from different firms. They present problems faced by different users and we all contribute towards solving such problems. Such activities are a valuable opportunity for local knowledge transfer and learning"*

This mechanism of consultants shows that when they are not knowledgeable about a particular problem they stimulate learning by nurturing an environment conducive for learning-by-interaction among different users. Respondents highlighted that, due to the specialization of consultants in the industry, users perceive them as knowledgeable and credible sources of knowledge and users accept their suggestions or judgement. Accordingly, when local consultants call for technical gatherings, users respond positively and contribute to the meetings.

In addition to enhancing learning among different users, consultants raise the awareness of users in the industry about the experience of successful firms that adopt particular technologies or techniques. According to a section head:

*"...Learning about successful experiences in the industry stimulates our demands to adopt similar solutions that have already been proved successful in similar contexts. They [consultants] help us learn how to adapt the solutions of successful firms to our specific context"*

As highlighted by several respondents, the functions of consultants identified above illustrate the influence of their specialization in the industry and their proximity to users. Specialization made local consultants knowledgeable about several areas of the industry in which they offer their services along the

technology transfer. Likewise proximity enhances communication and sharing of knowledge between the two sides.

Nonetheless, interviewees noted the differences between local industrial consultants and specialized industrial consultants in terms of their ability to adapt and customize knowledge to the local context. Specialized consultants focus on a limited area of the industry and have minimum knowledge about local operating contexts. On the other hand, local consultants are limited in their consultancies and advice on systems or technologies that are similar to options that have already been adopted and adapted to local context.

Respondents highlighted that knowledge about the industry is only a single element for a successful knowledge transfer and learning from external sources. The complementary and crucial element is knowledge about the local context on which the external knowledge will be used. Accordingly, the specific knowledge of specialized consultants is customized and adapted by local consultants who possess rich knowledge about local contexts.

As local industrial consultants have accumulated their experience mainly from similar users, they are less supportive when the required solutions are new or beyond their past experiences. In such cases, specialized consultants are more supportive to users when the problem being analysed or solutions required are new to the local context. Respondents believe that specialized consultants are exposed to a wider range of experiences that are not limited to a particular context, thus they have the capability to bring new inputs to different users. In addition, due to the specialization on particular technological domain they also possess a high level of prior knowledge on that specific domain. Moreover, respondents suggested that specialized consultants have internal R&D facilities through which they produce new technologies or explore new ways for exploiting existing technologies.

Respondents in BETA also noted the influence of users on the functions of consultants along the transfer process. The influence of users is a function of their prior knowledge about the problem being addressed or the technologies/knowledge being transferred. Respondents described knowledgeable



users as active participants whereby they lead the functions of the transfer process instead of blindly following the instruction of intermediaries. The prior knowledge of users also ensures the quality of different functions of intermediaries along the different stages.

In some cases, when individuals of BETA lack prior knowledge (absorptive capacity) in particular aspects of the plant, it limits their influences on the functions of intermediaries, and bounds the individual's ability to learn from intermediaries along the transfer process. A senior manager who was assigned to work with an international specialized consultant reported that he failed to influence the functions of consultants, as he did not possess a sufficient level of prior knowledge about the project to which he was assigned. In addition, he failed to learn adequately from experienced personnel of the consultants, mainly due to a lack of prior knowledge about the projects being implemented.

While BETA deals with local and specialized industrial consultants, it was found that it does not cooperate with university consultants. Several respondents justified this due to BETA's heavy reliance on international alliance partners that provide BETA with the necessary advice and knowledge. In addition, some respondents noted the lack of BETA's interest in R&D activities as another reason for the lack of university-BETA linkages. Moreover, the lack of awareness on both sides about the potential of the other side was also suggested as a reason leading to the weak linkages. According to a section head who had joined BETA since its establishment:

*"...To the best of my knowledge we have weak linkages with university researchers. We seldom involve them in our problem solving and we rarely seek advice from them. We tend to rely on the industrial-based consultants"*

This basically means that there is minimum level of knowledge transfer from universities to BETA. However, similar to other firms in the country, BETA recruits university graduates in different positions of the company. Recruitment is noted to be the only channel of transferring expertise and skills from universities to BETA. When asking the section head about the lack of involving university professor as consultants he responded:

*"...I was working for ALPHA and I had personal experience in dealing with university professors. They lack the industry and context specific knowledge. Their consultancies are in general areas to the industry without much adopting them to our specific use. Even when they [university professors] provide advice, we have to simplify it for our individuals to understand"*

This shows the influence of a lack of cognitive proximity between university professors and BETA. This hinders the transferability of knowledge from universities to BETA.

Several respondents suggested an important reason why BETA relies on industrial consultants more than the university consultants. Not many of BETA's personnel are educated to a higher academic degree such as Masters or doctorates. Consequently, there is a perception that the lack of highly educated personnel in BETA has reduced its awareness of the potential of local university researchers - consultants. In addition, the lack of highly educated personnel made it harder for BETA to learn from universities as a result of weak internal absorptive capacity and hence ability to understand scientific language.

The above analysis presented BETA's description to the main characteristics of consultants. Respondents differentiate between different consultants mainly based on their industrial knowledge (specialisation) and proximity to local contexts. The knowledge and experience about the industry is only one element in the technology transfer through intermediaries. The balancing element is the ability to adapt that knowledge to suit the specific local context. It was also clear from various respondents that users perceive consultants with industrial experience a reliable and credible source of knowledge.

Having presented the characteristics of consultants, the following section presents the characteristics of agents.

#### **6.4.3 TECHNOLOGY AGENTS (MANUFACTURER REPRESENTATIVE)**

The second type of intermediary that supports BETA along the transfer process is agents of technologies that represent different regional or global producers or other agents. In a field interview, a team leader stated:

*"...They [agents] often don't own the product or the service they offer. They link us to their network of suppliers and we perform the tasks that are required to accept or reject a solution"*

BETA recognizes that agents are embedded in a network of regional and global suppliers. According to a section head, agents helped BETA in different functions including identifying sources of technologies once BETA specified technologies, linked BETA with different suppliers and facilitated communications, informed BETA about the legal and administrative procedures required in the country of origin of the technologies, performed the logistics to transfer technologies from their sources, including packing the selected technology to be transferred, customs clearance, transported technologies to the plant after they arrived at the local port, and finally were sometimes involved in installing technologies at their final location.

Several respondents highlighted that local agents are not necessarily equipped with all the knowledge or skills required to perform all these tasks, but the fact that they were embedded in a network of other agents allowed them to access a wide range of skills and knowledge. For instance, according to a section head, local agents were not really aware about the legal system for all external sources of technologies. However, through other agents they became aware of that and consequently they informed local users such as BETA.

This notice highlights that the main function of agents with BETA is to enhance BETA's accessibility to a wider options of technologies or solutions from different sources. While there is no doubt about the significance of the linkage function of agents, respondents emphasized that agents do not add value beyond the linkage role, such as assessing the credibility of different producers or the suitability and adaptability of different options. Nonetheless, the ability of local agents to enhance the BETA's accessibility to networks of producers reveals that agents are embedded in a strong network of other agents or network of producers.

Respondents also highlighted that agents are rarely exposed to real work experience in the industry; consequently they lack industry specific knowledge. Therefore, their ability to assess various options for the sake of the specific

applications of the industry or to adapt external technologies is also limited. Moreover, respondents noted that agents hardly transfer a sufficient level of technical knowledge associated with technologies. This, according to respondents, can be discovered from the quality of knowledge being transferred by agents to local users. This knowledge is often limited to codified knowledge in manuals or brochures provided by original producers of technologies. According to a senior field engineer:

*"...Although they [agents] offer services or products to the industry, they haven't worked in the industry thus they lack the industrial knowledge".*

*"...They [agents] market technologies through the knowledge printed on shorthand [manuals]. Even with the abstract knowledge about technologies in those notes [manuals], they [agents] are not really capable of explaining or simplifying it [knowledge] if it requires so"*

Transferring knowledge associated with technologies to local industry requires the ability of agents to absorb that knowledge from their sources so they, in turn, can diffuse it to local industry. However, the low level of knowledge diffused reflects the modest capacity of agents to absorb knowledge from original sources of technologies. As the absorptive capacity is a function of prior related knowledge that is accumulated as a result of specialization, the lack of specialization of local agents is noted to hinder their ability to make effective knowledge transfer from source to recipients. In contrast, specialized agents possess an advanced level of prior knowledge that enhances their ability to absorb technologies from sources and become more capable of diffusing technologies to local users.

For instance, several respondents mentioned the ability of specialized agents to process information (simplify and articulate knowledge) about technologies. This ability, according to respondents, is a function of their prior knowledge about technologies. Respondents at this point differentiate between specialized versus non-specialized agents, based on prior knowledge (specialisation) about the domain of technologies they supply. The lack of knowledge processing capability of local agents meant that they were involved in the transfer of simple and codified

technologies that did not require great efforts of knowledge processing. As a technical section head said:

*"...They [non-specialised agents] are mostly involved in the transfer of products or services that do not require significant knowledge transfer such as the storage tanks, pipes, chimneys, or simple control valves. Some agents supply computer software that comes with its instructions and procedures that our employees can follow without the need for great technical support from agents"*

However, when asking respondents about the functions of specialized agents they highlighted that this type, although knowledgeable about their products or services, are often isolated from local contexts. They supply specific technologies to a wider range of users across different sectors thus they leave the tasks such as adaptation, modification or any changes required for the adaptation, mostly to individual users. Nonetheless, interviewees found specialized agents were helpful in learning about new technologies within their technological domains. They simplify and articulate knowledge related to those technologies to a level absorbed by local users. However, as they lack knowledge about the local contexts, specialized agents were less supportive in adapting their product to local users. As one of the managers noted:

*"...They [specialised agents] help us learn about their products but we adapt the products to our specific applications"*

An important element highlighted by several interviewees about both agents, specialized and non-specialized, was their cognitive proximity with users in terms of sharing a common language or understanding about the industry. Respondents highlighted that as local agents had not been exposed to real work experience in the industry, they lacked adequate organizational knowledge, language, culture or capability. They did not share a similar understanding of the industry to users. The differences in these elements developed a lack of cognitive proximity between agents and users, which in turn made the communication and the knowledge flow slow and difficult. According to a team leader:

*"...We [BETA and agents] rarely share common understanding on the problem we face. They don't have the knowledge we have about the industry. We found the lack of commonality such as understanding, and knowledge base hinders the communication and knowledge sharing"*

The lack of cognitive proximity has a negative influence on BETA's learning. Diffusing external technologies to the local context requires simplification and interpretation of knowledge via a common language to ensure local users can absorb it. In asking whether agents (specialized and non-specialized) were keen to learn about the context of the industry or to develop further capability to support the user's learning, the respondents answered with a direct reference to the strategic objectives that BETA aim to achieve from the transfer process. Where there were strategic commitments to learning about the technologies being transferred, BETA selected a competent supplier who could support the learning objectives. In contrast, when there was a lack of strategic commitments, the capability of suppliers becomes a secondary issue in supplier's selection criteria.

Respondents emphasized the role of corporate technology strategy in driving the development of supplier's technological capability. According to several section heads and field engineers, the strategy defines the resources allocated for learning including the capability of suppliers to achieve the strategic objectives. When learning is considered as a strategic objective, a competent and capable supplier is selected for the transfer project. This drives intermediaries to upgrade in order to become a technology transfer partner with BETA.

Due to the growth in demand for external technologies, there was also an accompanying growth in the number of intermediaries to support local users. Respondents highlighted that a large percentage of those intermediaries lacked the capability to support the local learning. Most of them were money seekers that offered different moneymaking services or products to local firms. However, due to the low level of capability, these activities may not be effective for long-term sector-wide learning. By defining the capability of suppliers through different sets of technical standards, the strategy will enhance the development of the technical quality of intermediaries so that those operating in the sector possess a certain

level of technological capability. This function of the strategy will regulate the technology transfer market and reduce the occurrence of low quality intermediaries that emerge in the market on a continual basis.

#### **6.4.4 TECHNOLOGY INTERMEDIARIES: SUMMARY OF BETA**

The analysis of data from BETA revealed several characteristics of consultants and agents that were involved in different functions along the transfer process. Respondents differentiated between the two intermediaries mainly based on two factors, namely the specialization (prior knowledge about the industry) and the proximity with local users. These factors not only distinguished agents from consultants but also distinguished specialized from non-specialized intermediaries. Moreover, these two factors determined the type of technologies that each type could transfer. While local agents were mainly involved in the transfer of simple and codified technologies, consultants were more supportive in the transfer of tacit or complex technologies. The analysis also disclosed that agents mainly played a linkage role with BETA, whereas consultants were more involved in terms of learning by training users or by adapting external technologies to local contexts. In addition, the interpreter function of consultants plays a significant role for user's learning from external sources.

Industrial consultants were viewed reliable and credible sources for valuable knowledge. Interestingly, BETA did not approach local university consultants as a source for external technologies. Instead, industrial consultants were in great demand. Consultants from the strategic alliance played key roles in the technology transfer for BETA. The lack of internal absorptive capacity in terms of scientific language was suggested as a reason for the lack of university-BETA knowledge transfer.

Having discussed the main characteristics of consultants and agents as perceived by members from BETA, the following sections present the different functions of both intermediaries, and highlight the factors that influence their functions along the various stages of the transfer process.

#### **6.4.5 FUNCTIONS OF INTERMEDIARIES ALONG THE TRANSFER PROCESS**

This section analyses and presents empirical data from BETA about the functions of consultants and agents along the four stages of the transfer process as defined in Section 2.4.1. The functions of the two intermediaries will be examined from the lenses of the four suggested factors of proximity, specialization, characteristics of technologies and the capability of users. The analysis will highlight whether these four factors influence the functions of intermediaries with BETA, and how. Moreover, the analysis will recognize any emergent factors that might be highlighted by interviewees to influence the functions of intermediaries.

- DEMAND ARTICULATION

BETA identifies demands either through internal efforts such as problem solving, strategic planning sessions, or through external partners from the strategic alliance. Internally, field engineers and operators at the plant record problems they face and report suggestions that they think might enhance the plant's operation. Through problem-solving sessions and strategic planning, the feedback from the plant's engineers is analysed to define any problems and identify how to address them. Alternatively, demand is also stimulated by BETA's international partners who suggest the adoption of particular technologies based on their knowledge of the experience of successful users.

Respondents highlighted that intermediaries who were involved in demand articulation were knowledgeable about the plants where technologies are employed. Moreover, they were typically close to users in order to understand and articulate their demands. This knowledge helped intermediaries to analyse the operation of the plant in order to identify problems (when there is a problem), or to think of opportunities to enhance the performance of the plant. Accordingly, when BETA's engineers lacked the capability to identify or define a problem that the plant faced, they sought external assistance from knowledgeable consultants. Such consultants were often local or from the international alliance, who are, according to the respondents, more experienced and specialized than locals.

During the demand articulation stage, industrial consultants helped define problems being faced and specified the solutions that might help in addressing those problems. In addition, they stimulated demands for technologies beyond the



consideration of BETA. Consultants stimulated BETA's demands by sharing the successful experiences of different users they are connected to. According to a senior field engineer:

*"...Some technologies are identified and suggested by our local or international partners [consultants]. They recommend the adoption of certain technologies and support the transfer process of that option"*

An important factor that influenced the functions of intermediaries at this stage is the characteristics of the problem being analyzed or technologies being transferred. These characteristics are such as technical complexity, tacitness or novelty determine the knowledge and capability of intermediaries who can transfer technologies or diagnose the problem. Respondents highlighted that local consultants were heavily involved in defining problems within the system as long as these were related to technologies being already used, that is, these were similar to existing. This was mainly due to the fact that local consultants accumulated their knowledge based on working in the local industry – limited sources of experiences. Consequently, their knowledge and contribution were locked-in the knowledge accumulated from the limited local experiences.

In addition, local consultants did not possess technology production capacity such as R&D activities, thus their ability to introduce new input was limited. In contrast, international consultants were reported to be more involved in defining unique problems or analysing systems that have novel or new characteristics.

This discloses the effect of too-close proximity of local consultants with users. It locks-in local consultants in the local experience and hinders their ability to transfer new knowledge. In contrast, international specialized consultants are not in a very close proximity to local users. In addition, they have their internal knowledge production capacity (R&D) through which they generate new knowledge or identify new functions of technologies. In addition, international consultants are exposed to wider experiences from different users across the globe.

In contrast to consultants, respondents highlighted that, due to the lack of industry-specific knowledge with agents, they were rarely involved in the demand articulation stage. According to a field engineer who articulated a commonly held view:

*"...Their [agents] knowledge about the system is modest, thus it is difficult if not impossible for them to analyse the system or suggest improvements"*

However, users highlighted that although agents were not involved in the demand articulation stage, they stimulated users' demands for certain technologies. Different respondents mentioned the supply-push approach that local agents followed to transfer technologies to local users. In an interview with a field supervisor he said:

*"...They [agents] continuously visit us marketing new products to persuade us to purchase them. We consider them [products] for any future needs. In some cases we find them [products] suitable and support our operation, thus we acquire them"*

This stage leads to defining the problem or future opportunities. Moreover, it specifies the characteristics of the option (technologies/solutions) that might address the present problem or meet future opportunities. These trigger the search process for external technologies or solutions to meet the demands.

- MARKET SCANNING

This stage identifies a range of options that are available in the technology market and that can meet the demands or address the challenges. It also assesses the different options in order to select the most compatible option that has the potential to answer the demands, and is also adaptable to the existing system. This stage requires access to a wider network of sources of technologies to identify a range of options, information about the various options of technologies and the ability to assess them, and knowledge about the context of applications to ensure the adaptability and compatibility. Moreover, it requires the ability to diffuse information about technologies to enhance the assessment process.

Consultants that are involved with users at this stage are often international consultants from their strategic alliance. These consultants are connected to a global network of suppliers and to other consultants. In addition, they are themselves, in some cases, producers of new technologies. In contrast, local consultants were reported to be limited in their accessibility to external suppliers of technologies. However, local consultants support BETA in tasks related to the assessment of various options once they are identified. Based on their knowledge about the system of users (specialisation), local consultants assess, prioritize, and advise on the suitability of options for the particular applications.

As mentioned before, respondents found local agents were embedded in a broad network of suppliers through which users access a larger scope of options. Accordingly, they enhanced the accessibility of local users to options that might be inaccessible without their network. Moreover, they informed local users about the various requirements (legal and financial) to transfer each option. However, as they lacked industry specific knowledge and experience, they were found less capable of advising on particular options. Moreover, as agents are not specialized in the industry nor in a technological domain, their prior knowledge about technologies was modest, which hindered their ability to simplify or interpret external knowledge. This, in turn, hindered their capability to assess different options in order to suggest the best compatible option. Moreover, they were less capable of diffusing sufficient information about technologies to support the assessment, especially when technologies were tacit or complex that constitutes different functionalities. Therefore, their main function at this stage was linking users with a network of producers. According to a section head:

*"...Although they [agents] are not knowledgeable about the internal operating conditions, they increase our accessibility to more options that are difficult to access without their network"*

Therefore, based on the network of agents and the assessment capability of consultants, BETA takes the adoption decision to transfer the most compatible option. This leads to the subsequent stage – acquisition.

- ACQUISITION

According to a plant supervisor, the key task of this stage is to bring the option being selected and install it in the plant. This stage involves several tasks such as developing the transfer agreement, such as the agreement on the specifications and rights attached to technologies, agreement on post-transfer services and training, and the logistics associated with the actual transfer of the technology.

Both agents and consultants support users at this stage. According to various respondents, agents link users with suppliers and develop the transfer agreement as per the terms and specifications of users. They also carry out logistical tasks to bring technologies from their suppliers to the location where it will be used. In addition, they inform users about all the requirements needed prior to importing external technologies. These tasks were highlighted by one of the managers when he said:

*"...They [agents] help us significantly during this stage. We don't have and we don't want to have the internal capacity to perform the logistical tasks associated with bringing the technologies from their sources to our locations"*

Another section head pointed out:

*"...Their knowledge about the legal requirements is very helpful at this stage"*

However, respondents highlighted that while agents performed the actual import of technologies from their suppliers, they rarely interacted with original suppliers to ensure effective absorption of knowledge prior to bringing technologies to local users. Instead they transferred technologies as a normal commodity with little involvement in transferring the associated technological knowledge. Moreover, agents were reported to lack sufficient human resources necessary to interact with suppliers to ensure an effective transfer. Consequently, the physical part of technologies was transferred to local users without adequate knowledge to drive the local learning. In addition to the lack of absorptive capacity, agents and suppliers were also located in two different locations. This develops a lack of cognitive and geographical proximity between agents and suppliers. As several field supervisors noted:

*"...They [technologies] are often imported as black boxes without knowing the details of the product. Some technologies require more knowledge to learn about, thus, in the absence of sufficient knowledge, learning becomes difficult. Their [agents] weak prior knowledge is the main obstruction to the actual knowledge transfer"*

In contrast to agents, consultants were reported to perform other supportive tasks that enhanced users' absorption of external technologies. Several respondents intensively highlighted the supervisory and policing function of consultants at this stage. Consultants supported users in ensuring technologies being acquired met and matched with the correct specifications and characteristics that had been identified during the demand articulation stage. They also simplified and interpreted technologies through a common organizational language. Moreover, where agents do not transfer sufficient knowledge with technologies, consultants employed their prior knowledge and ensured users were capable of absorbing technologies in terms of operation and maintenance. In addition they also supported the adaptation of technologies into existing systems and trained users in their effective use. Various respondents have noted these different functions of consultants. According to a plant supervisor:

*"...They [consultants] are the masterminds of this stage. They complement what those [agents] have missed. They [consultants] perform several tasks from simplification and interpretation of information through to adaptation and training. They also ensure that agents perform their tasks as per the agreement and that the conditions and specifications were met"*

As already highlighted, when technologies differ from those already existing or have novel features, specialized consultants are invited either to supervise the actual transfer or to act as a source of the new technologies. The outcome of this stage is the installation of the option being acquired. The next stage is learning to use and internalize that option.

- DIFFUSION AND UTILIZATION

The last stage in a technology transfer project with BETA is the utilization (deployment) of the technology being transferred. According to a section head:

*"...The successful utilisation of technologies often means the success of the technology transfer project. The last step is when it [technology] is employed for the purpose it was originally imported for"*

Due to the capability required at this stage for different functions such as adaptation, combining different technologies, making the necessary changes if required on the existing system, simplification of complex technologies, codification of external knowledge, and training users on the new technologies, respondents reported the heavy involvement of consultants. That is, according to respondents, mainly because the nature of most of these functions requires sophisticated technological capability that industrial-consultants often possess.

According to a section head, adaptation of external technologies in some cases requires major changes in the set-up of the internal system in order to install and couple the new technologies. Making such changes requires knowledge about the external technologies and internal systems so the match and compatibility can be achieved. Moreover, consultants also support users in codifying and recording the knowledge associated with the technologies for future reference.

The plant engineers emphasized the importance of the codification as it helped future users learn about existing technologies. External knowledge from suppliers is translated into organizational language and jargon so it can be easily diffused internally and understood by different individuals. In addition, consultants also train users through demonstrating the functions of the technology, which allows users to better understand the operation and maintenance of technologies. These functions of consultants are enhanced, according to a section head, by their specialization on the industry and their proximity to users. They possess prior knowledge about the technologies and they also share common understanding and common organizational language with users to facilitate the communication.

Agents, on the other hand, were reported to marginally participate at this stage. Respondents highlighted that the nature of the intermediation functions at this stage is intellectual, which requires an advanced level of absorptive and disseminative capacities. Agents were found to possess modest levels of these capacities, thus the nature of their intermediation functions are mostly physical.

Although that requires a certain level of absorptive capacity, it is not advanced level similar to adaptation function, for example.

Nonetheless, despite the different functions of intermediaries and the different efforts of BETA to support the transfer process, interviewed engineers highlighted that BETA does not perceive technological learning along the transfer process as a standalone strategic goal. Technologies were transferred mainly to enhance or improve productivity through reducing costs of operations, enhancing safety and protecting the environment.

BETA's technological learning aims, at best, to develop the adaptation capability, which until now was performed mostly by consultants. BETA does not aim to develop and implement technological learning for innovation (*stricto sensu*). According to several respondents, the company does not allocate resources for advanced learning that aims to improve operations or the performance of existing technologies, let alone to produce innovation. Moreover, the participation of BETA's personnel in scientific conferences or publishing journal papers is almost absent.

Field engineers intensively emphasized that resources provided for learning were limited to training and education that aimed to develop the capability necessary to supervise and manage the overall operation of the plant, in addition to operate and maintain plant. Importantly, as BETA does not recognize learning as a standalone objective, the technical criteria of the suppliers of external technologies were not defined to achieve learning. Respondents believed that if the corporate technology strategy recognized learning as a strategic objective of the transfer process, then several changes would occur. These changes might include the selection of competent suppliers, including agents and consultants, the selection of competent engineers involved in the transfer projects. Moreover, training and education opportunities would be guided by the objectives of the strategy to ultimately generate innovation through improvements of the transferred technologies. This would drive local suppliers to develop and upgrade their capability to meet the standards and requirements of users. According to a section head:

*"...We [the firm] can drive their [suppliers] technological development by introducing a set of technical criteria for suppliers who can be accepted in our tenders"*

Since BETA does not insist on advanced technological capabilities of suppliers, local intermediaries do not invest in advancing their capabilities either. According to several respondents, this weak capability of most local agents was partially a result of the absence of BETA's recognition of learning as a strategic goal of the transfer process. Respondents believed that the goal of technology transfer could drive the development of the capability of local intermediaries. For this to happen, it was suggested that an incentive system was introduced, through which intermediaries with advanced capability were favoured to win the transfer projects over those intermediaries with weak capability.

#### **6.4.6 CASE SUMMARY: BETA**

The analysis of BETA's empirical data revealed that both agents and consultants support the transfer process through different functions. BETA was found to rely heavily on specialized consultants from their strategic alliance rather than on local consultants or agents. According to interviewees, that was mainly due to the special technical support required for technology transfer, including identifying the demands and adapting external technologies to the local context. Moreover, there was no other plant similar to BETA in the country, thus the experience of local consultants was based on a single plant. Accordingly, the experience might not be adequate to support effective transfer of external technologies; there was, therefore, a need for external specialized consultants.

Surprisingly, BETA does not seek support from university-based consultants. Several respondents suggested that the lack of university-BETA cooperation was a consequence of BETA's weak internal absorptive capacity in terms of scientific capacity. Moreover, BETA perceived that university consultants also lacked awareness about the industry-specific demands and contexts of applications. Additionally, it is thought that BETA's strategic alliance binds the firm to particular sources of external support. Therefore, BETA expected the support of university



consultants to be of minimal value to their business at this stage of their development.

The analysis of data from BETA confirms the initial suggestion that the four factors of proximity, specialization, technology and capability of users influenced the function of agents and consultants along the transfer process. In addition to these four factors, BETA's technology strategy emerged as a new factor influencing the functions of intermediaries. The technology strategy influenced the functions of intermediaries by driving the development of their capability to support users' learning.

## ***6.5 CHAPTER SUMMARY***

This chapter presented the within-case analysis reports of ALPHA and BETA individually to become familiar with the similarities and differences between them on the functions of intermediaries, and factors influencing those functions along the transfer process. The study aimed to identify the different functions of consultants and agents along the transfer process and examined the factors that influence those functions. The examination of the functions of intermediaries was guided by the proposed four factors of the conceptual research framework and to the central purpose of the study. These factors are the proximity, specialization, characteristics of technologies, and the capability of users of technologies.

The findings of the analysis confirm the initial thought of the research conceptual framework, which suggests that the set of these four factors influences the functions of intermediaries along the transfer process and, in turn, influences the learning process. In addition to those four factors, corporate technology strategy emerged as a new factor influencing the functions of intermediaries along the analysis process.

Based on these factors, the study identified three categories of consultants, namely industrial general, industrial specialized, and university consultants. Likewise, agents were categorized into two sub-categories, namely general and specialized.

This categorization adds to previous studies on technology intermediaries that limit their analysis of intermediaries to identifying their functions and dealing with them at the general level as agents or consultants, without separating them to specialized or non-specialized. This study not only mapped out the functions of intermediaries but also identified the factors influencing those functions and added categories to intermediaries.

The analysis of this study was based on the theoretical stance of technological learning. Given that users are isolated from technological sources and that they possess weak internal knowledge production capacity, the study found intermediaries play a central role in terms of supporting user's learning along the transfer process. Local firms perceive consultants as more credible and reliable sources for valuable knowledge that drives learning in comparison to agents. Moreover, the study found the four factors create a division of labour between consultants and agents along the transfer process. Whereas in most cases agents perform functions of a physical nature, consultants perform functions of an intellectual nature.

Accordingly, for effective technology transfer, a coordination mechanism between the different types of intermediaries should be developed to ensure all intermediaries complement the functions of each other to support users' learning. Moreover, the analysis revealed that effective technology transfer requires adequate knowledge about two main sides - the technologies being transferred in addition to the context of applications. The lack of knowledge about one side was noted to hinder the successful adoption (selection) of external technologies and effective adaptation and internalization of external technologies.

An important finding is that technology transfer through intermediaries in many cases does not go in a direct transfer process from producer to users through intermediaries. It could go through multiple transfer processes (intermediaries) until it reaches the final destination – local users. This transfer process through multiple actors adds to the complexity of technology transfer. This is because the breadth and depth of technologies that finally reaches the local users largely

depends on the capability of different actors (intermediaries) involved along the process.

Moreover, the study found that the internal capability of firms directly determines the type of intermediaries they interact with and the functions they performed along the transfer process. For instance, while ALPHA was found to cooperate with university consultants, BETA was found not to deal with them. ALPHA possesses the internal capability to describe the tasks of university consultants and determine the area for their consultancy. On the other hand, BETA relies heavily on consultants from their strategic alliances or local consultants who are experts in the industry.

Based on the findings achieved by analysing each case individually, the following chapter will compare the findings of the two cases in what so-called cross-case analysis.

## **7 CROSS-CASE ANALYSIS**

### ***7.1 INTRODUCTION***

The previous chapter presented the empirical findings of the within-case data analysis reports for each case study. The analysis identified the main functions of consultants and agents during the transfer process, and recognized five factors that influence intermediaries' functions along the transfer process, which in turn influence user's learning. The first four factors (proximity of intermediaries with respect to users; specialization of intermediaries; characteristics of technologies being transferred: capability of user firms) were proposed in the research conceptual framework while the last factor (user firms' technology strategy) emerged from the data analysis.

The aim of this chapter is to compare the empirical findings from the two firms through cross-case analysis in order to generate a more general explanation that fits each individual case, even when their details differ (Eisenhardt, 1989).

The previous chapter found that industrial consultants play central roles in effective technology transfer and learning. The weak internal technological capability of local firms means they typically request external technical support during the transfer process. Due to the lack of internal capability of firms in the sector, the different functions of intermediaries has improved the firms' learning by internalizing external technologies. However, five factors were found to influence the functions of different intermediaries along the transfer process and therefore firms' learning. Not all intermediaries support learning along the stages of transfer process, and not all are even keen to invest to support learning. This has serious and negative implications on learning for firms that are isolated from most technological sources and possess weak internal capability, such as the firms examined in this study. The empirical findings highlighted the firm's technology strategy as an instrument that might be used as a kind of market regulator to drive the technological development of suppliers to enhance their contributions to firms' learning.

An important element of the cross-case analysis relates to theoretical analysis of the findings. To do so, the study's findings are compared to findings from previous studies in order to highlight similarities and/or differences. This is not necessarily an easy task as there is a general lack of studies about which factors influence the functions that intermediaries undertake, particularly within developing countries or the oil and gas industry. Most previous studies explore particular functions of intermediaries such as the linkage or brokerage functions (Li-Ying, 2012; Shohet and Prevezer, 1996). In contrast, this study explores all the possible functions undertaken by intermediaries to support technology transfer and learning in the oil and gas industry. Moreover, it identifies the factors influencing those functions.

In addition to a short introduction and summary, this chapter includes three main sections. The first section presents and discusses the empirical findings about consultants and agents, and highlights their characteristics and their functions along the transfer process. The second section presents and discusses the factors that influence those functions. This is further developed in the third section into a modified conceptual framework that can be used for future research.

## ***7.2 TECHNOLOGY INTERMEDIARIES IN THE OMANI OIL AND GAS INDUSTRY: FUNCTIONS AND INFLUENTIAL FACTORS***

The empirical findings highlighted that local firms turn to technology intermediaries for a variety of reasons that go beyond simple technology outsourcing or accessing external sources of technologies. Local firms are isolated from most sources of technology, and lack an internal knowledge-production capacity. Moreover, local firms may lack the capability to manage entire technology transfer projects, or lack the particular capability required for certain stages of the transfer process; hence they turn to technology intermediaries to complement their internal capability.

This study identified two main intermediaries as being active in the technology transfer market for the local oil and gas industry: the case study firms referred to these intermediaries as consultants and technology agents. The case study firms classified consultants into three categories including industrial general

consultants, industrial specialized consultants, and university consultants. Agents were also classified into two categories, specialized and non-specialized. This classification is based mainly on specialization and proximity of intermediaries, which also influences their capability as technology transfer actors. The following sections describe the characteristics and functions of the two intermediaries.

### **7.2.1 CONSULTANTS**

Respondents highlighted that consultants gain their knowledge and experience either from working in the industry or through R&D activities. Accordingly they are categorized as industrial consultants or university consultants. Industrial consultants are often retired engineers who have previously worked in the oil and gas industry (or similar), and who therefore belong to the users' community of practice.

The main characteristics of industrial consultants are their proximity to users in the industry, especially cognitive proximity, and their specialization in the industry. They share common understandings on the industry with users, including using similar language, and having similar knowledge and experiences. This made industrial consultants in a cognitive proximity to users, which facilitates communication and knowledge transfer between them (Boschma, 2005).

Moreover, industrial consultants are either general and offer their technical support in a range of areas across the industry, or they are industry-specific and specialize in a limited area or technological domain within the industry. Specialized industrial consultants can therefore help transfer specific technologies (Bessant and Rush, 1995), and they work within specific technological domains (Howells, 2006).

Local industrial consultants were found to be general and offer their consultancy in different areas across the sector. Moreover, they lack R&D capacity, which influences their ability to transfer new technologies. Specialized consultants, on the other hand, are not located in the country and are exposed to a wide range of industrial experiences of different users on a global scale. The wide exposure was described as enhancing their capability to understand the needs of different users

in different contexts. As a result, they could identify new applications for existing technologies, or even produce new technologies to meet the changing demands of the industry. Such specialized consultants were also reported to conduct their own R&D activities, which enhances the production of new knowledge.

While both types of industrial consultants are in a cognitive proximity with users (share of similar understanding to the industry), they vary in their geographical proximity. Local consultants are located near local users while most specialized consultants are located in industrialized countries. This is, according to various respondents, mainly due to the need of specialized consultants to gain access to advanced R&D infrastructures, such as knowledge resources and research laboratories, that are not available in most developing countries (Viotti, 2002). This difference in proximity, as will be discussed later, caused each type to perform different functions and be involved in transferring different types of external technologies. Finally, consultants also vary in size, from being a one-man show, to being a large organization that offers consultancies in different areas to the industry. The main characteristics of consultants are compiled in Table 7-1.

**Table 7-1: Characteristics of Consultants Based on Proximity and Specialization**

	Industrial consultants		University
	General	Specialized	
Background	• oil and gas or similar industry such as manufacturer		• Research
Proximity (Geographical)	• Often located locally with users	• Often based in industrial countries	• Universities or research centres
Proximity (Cognitive)	• Often limited to local users and contexts (lock-in)	• Exposure to more users in a global scale, in addition to internal R&D activities	• Often lack adequate industrial work experience
Specialization	• Across the industry and their experience is mainly based on already existing technologies or techniques	• Specific and often new technologies or new applications. • E.g.: measurement and test technologies, field monitoring units, data acquisition units, SCADA, health, safety or environmental issues • R&D capacity	• Science based, and in specific areas

Source: compiled by the author

Respondents from the two firms agreed on the capability of industrial consultants to contribute to their internal learning. Consultants as industrial retirees were described performing several significant functions to support local firms' learning, including simplifying and interpreting external knowledge, linking local users together and sharing experiences, identifying and articulating or stimulating demands for external technologies, and providing development and training programmes to enhance the diffusion and localization of external technologies.

In contrast to industrial consultants, the supports of university consultants, given their lack of practical industrial experience, were limited to providing scientific advice on problem definition and providing some education and training programmes that were specified by the users. Although ALPHA sought some assistance from universities, BETA had very minimal or no interactions with university researchers, which was justified by their weak internal technological capability and lack of highly qualified personnel. Engineers from BETA highlighted that, BETA does not support its employees' education for higher degrees beyond the bachelor level, with the result that their personnel tend to be educated to degree level, with a few MSc, but no PhDs.

On the other hand, respondents also reported that university consultants do not make sufficient effort to simplify their knowledge to a level that could be understood by individuals in the industry. This illustrates how a similar language creates a base for communication and information sharing (Grant, 1996). The lack of common language and understanding about the industry limits communication between university consultants and BETA, with the result that the latter do not interact with the former.

In contrast to BETA, ALPHA involved university consultants in their problem solving and training, and it also supports the engagement of its employees in higher education programmes. As presented in the cases' background, ALPHA's personnel are educated up to PhD level, and the firm's internal absorptive capacity might therefore explain their ability to recognize and interact with universities and absorb external technologies from researchers. Such qualified individuals play significant roles in interpreting and simplifying scientific language to a level that



can be disseminated and understood within firms, as also this has been highlighted in previous studies (Kumar *et al.*, 1999).

While specialized industrial consultants and university consultants participate in problem definition, respondents highlighted that they were both challenged in communicating their knowledge to users. Both consultants lack understanding of technologies' potential applications for the specific local contexts. In the specific contexts of local users, local industrial consultants played the role of interpreters and translated external knowledge of specialized and university consultants and adapted it to the specific demands of different users.

The major differences between the specialized and general industrial consultants were the ability to communicate and adapt external technologies to local context, and the ability to transfer a new technology to local firms. While specialized consultants transfer new and fresh knowledge to local firms, general local consultants were locked-in the experiences of the local industry. The ability of specialized consultants to introduce new technologies is enhanced by their wide range of experience with different users in different contexts and by their internal R&D activities (Bessant and Rush, 1995; Boschma, 2005). Those specialised suppliers that have active internal R&D departments are the main source of new technologies in the oil and gas sector (Neal *et al.*, 2007; Pavitt, 1984). Pavitt (1984) has found that specialised suppliers drive the product innovation in the oil sector. Likewise, Intarakumnerd and Chaoroenporn (2013) emphasised that, specialised intermediaries are more dedicated to the development of the sector in which they operate.

Based on the above evidence, the different functions of the three consultants are summarized in Table 7-2. As illustrated, not all consultants perform the same functions nor they all are engaged equally with users along the transfer process. For instance, while general consultants are heavily involved with users along the four stages of the transfer process, university consultants are only involved in stages such as the demand articulation or suggesting solutions. Specialized consultants, on the other hand, perform demonstrations for the functions of new technologies they supply, and explain their technical specification and operating

conditions. In addition, general and specialized industrial consultants were found to follow a demand-pull approach for technology transfer. This approach transfers technologies based on recognizing the internal demands for external technologies prior to initiating the transfer process (Bessant and Rush, 1995; Szulanski, 1996). Industrial consultants, especially local ones, work closely with users to identify and articulate internal demands and, accordingly, suggest solutions that meet those specific demands. This direct interaction plays a significant role in enhancing the local firms' learning through direct transfer of knowledge and experience.

Having discussed the main functions of the different consultants along the transfer process, the following section discusses the main functions of agents. The factors influencing the different functions, or that make different intermediaries perform certain functions will be discussed in Section 7.3 of this chapter. Moreover, Section 7.3 will also discuss how those factors influence firm's learning.

Table 7-2 Functions of the Three types of Consultants Along the Four Stages of the Transfer Process

Transfer stage	Consultants		
	Industrial- (Local/General)  (Transfer technologies that are often <i>similar to existing</i> technologies)	Industrial- (Specialized) Specialized in specific areas of the industry  (Transfer <i>new technologies</i> or <i>new</i> applications for existing technologies)	University researchers (Science-based consultancy)
<b>Demand articulation</b>	<ul style="list-style-type: none"> <li>Analyse and diagnose system to identify problems</li> <li>Stimulate demands for potential opportunities</li> <li>Facilitate brainstorming, and strategic planning sessions</li> <li>Define specification or standards for potential solutions</li> </ul>	<ul style="list-style-type: none"> <li>Stimulate demands for new technologies</li> <li>Define specification or standards for new solutions – prescribe solutions</li> </ul>	<ul style="list-style-type: none"> <li>Identify and define problems based on scientific basis</li> <li>Stimulate demands for potential opportunities</li> </ul>
<b>Market scanning</b>	<ul style="list-style-type: none"> <li>Identify sources of potential solutions</li> <li>Process information for solutions similar to existing solutions</li> <li>Assess different options/prioritise and advise on compatible options</li> <li>Supervise the development of the transfer agreement</li> </ul>	<ul style="list-style-type: none"> <li>Identify sources of new solutions</li> <li>Assess different new solutions</li> <li>Process information of new solutions</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>Acquisition</b>	<ul style="list-style-type: none"> <li>Play a supervisory and policing role to ensure the transfer process is implemented as per the agreement and according to specifications being defined</li> <li>Ensure the transfer of the identified technologies</li> <li>Test, diagnose, analyse, and inspect technologies during the acquisition stage</li> </ul>	<ul style="list-style-type: none"> <li>Support the effective transfer of new technologies through information processing</li> <li>Support the testing, diagnosing, and inspecting new technologies</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>

<b>Diffusion and utilization</b>	<ul style="list-style-type: none"> <li>• Ensure the adaptability of external technologies to the operating environment and advise on the necessary changes required – matchmaking</li> <li>• Support the effective utilisation of existing technologies</li> <li>• Identify various functions of existing technologies</li> <li>• Train users on effective operation and maintenance of existing technologies</li> <li>• Translate and simplify external knowledge to local contexts</li> </ul>	<ul style="list-style-type: none"> <li>• Identify new applications for existing technologies</li> <li>• Identify various functions of new technologies</li> <li>• Train users on effective operation and maintenance of new technologies</li> <li>• Advise on the changes required to adapt new technologies to existing systems</li> <li>• R&amp;D facilities to generate and diffuse new knowledge.</li> </ul>	<ul style="list-style-type: none"> <li>• Provide training on technical fields identified by users</li> <li>• Support the production of new knowledge via R&amp;D facilities</li> </ul>
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### 7.2.2 AGENTS (MANUFACTURING REPRESENTATIVES)

The previous section identified that agents are often representatives of a wide range of regional and global suppliers, with the suppliers that agents represent not necessarily the original producers. Agents might acquire technologies from other agents within their network, which creates the potential for technology transfer to go through multiple actors (agents) until it reaches the end-users. The multiple agents along the transfer process might have different backgrounds, as Howells (2006) also highlighted, which potentially might create a communication gap (cognitive gap) that adds to the complexity and difficulty of technology transfer.

According to their technical specialization, agents were also found to be general or specialized. General agents supply different ranges of technologies that serve different sectors across the economy. Respondents described local agents as money seekers that offer different services or products to local firms, but these activities may not be effective for long-term sector-wide learning. Specialized agents, in contrast, focus on specific technological domains that might serve different sectors. Technology agents were typically found to have only small numbers of personnel, in most cases no more than seven. According to various respondents, local agents' personnel are trained more in marketing than in technical fields of technologies they supply for local users. The main characteristics of agents are presented in the following Table 7-3.

**Table 7-3: Characteristics of Agents Based on Proximity and Specialization**

	Agents	
	General	Specialized
Background	<ul style="list-style-type: none"> <li>• Representative to a wide range of regional and global suppliers of different sectors and different technological domains</li> </ul>	<ul style="list-style-type: none"> <li>• Representative to a wide range of suppliers that supply specific services or products</li> </ul>
Proximity (Geographical)	<ul style="list-style-type: none"> <li>• Often located locally with users</li> </ul>	<ul style="list-style-type: none"> <li>• Often located in large markets</li> </ul>
Proximity (Cognitive)	<ul style="list-style-type: none"> <li>• Lack industrial specific knowledge</li> </ul>	<ul style="list-style-type: none"> <li>• Lack the context specific knowledge</li> </ul>
Specialization	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• Specific technologies that serve several industries</li> </ul>

Agents perform key functions for local users along the transfer process. Respondents from the two firms agreed on the capability of agents to enhance the accessibility of local firms to a wider range of options from different sources. Agents performed several functions to support user's accessibility to external sources of technologies. They linked users with a range of suppliers, and supported firms in other administrative tasks such as legal advice and logistical tasks. They provided legal advice associated with the rights for transferring technologies, purchase and transfer agreements, and other related functions. These functions of accessibility and linkages have been also reported for agents in different contexts and experiences (e.g. Howells, 2006; Li-Ying, 2012; Shohet and Prevezer, 1996; Szogs et al., 2011)

However, agents were reported to add very minimal value to technologies they transfer. For instance, respondents mentioned that agents provided minimal support in knowledge processing such as simplifying, interpreting or analysing external knowledge to local users. Respondents agreed that agents have a very marginal role in technology assessment once it has been identified in the market. Consequently, they hardly contribute to the adaptation of technologies or to long-term learning. Specialized agents, on the other hand, supported learning by adding value to technologies they transferred, including articulation and simplification of technological knowledge.

Both general and specialized agents are less involved with users in demand articulation for external technologies. They often scan the market and suggest technologies based on their business interest or the interests of the original suppliers whom they represent. As such, agents in many cases follow the supply-push approach to technology transfer. Through this approach, agents approach users to adopt certain technologies, without adequate understanding of user's demands or specific applications. This lack of understanding of users' demands for external technologies before the process of technology transfer has been recognized among the reasons for failures in technology transfer (Andersson, 2009), particularly in the oil and gas sector (Woiceshyn and Daellenbach, 2005).

The lack of considering the demand and understanding the specifications of internal systems might generate difficulties in adapting the technology being transferred with the internal system (*ibid*). Consequently, technologies that are transferred through agents, without sufficient understanding of users' demands, need to be accepted with caution as it might lead to failure during the adaptation stage. Table 7-4 compiles and displays the different functions performed by the two types of agents.

### ***7.3 THE CURRENT RELATIONSHIP BETWEEN CONSULTANTS AND AGENTS IN THE LOCAL TECHNOLOGY TRANSFER MARKET***

The above empirical findings highlighted that consultants and agents perform different tasks for users along the four stages of the technology transfer process. Nonetheless, there is an overlap in some tasks performed by both intermediaries. For instance, both consultants and agents participate in the market scanning stage at different degree of involvement. However, as agents are more centrally connected to a wider network of regional and global suppliers, they are in a better position to support users to identify the various options of technologies that meet the specific demands.

In order for users to maximise their benefit from local intermediaries, they need to combine the efforts of both. However, according to various respondents, in addition to four intermediaries, currently there exists weak collaboration between

consultants and agents. Intermediaries highlighted that, due to the fear of losing a market position in the technology transfer market, they are reluctant to disclose to each other sufficient information about external technologies or the actual sources of technologies. Such information includes technical specifications, operating conditions and various sources, which all are crucial for the adoption decision. This weak collaboration has also been noticed by various managers in both firms, which according to them delay the technology transfer process. Beside the fear of losing market position, the lack of trust between consultants and agents weakens the degree of collaboration between them.

As will be highlighted in the recommendation section of this study, in order for local users to reap the maximum benefit of technology intermediaries, there has to be a coordination mechanism to be developed that combines the capabilities and efforts of consultants and agents along the various stages of the technology transfer process. Through such coordination, the end user users will be able to gain complementary benefits of both intermediaries.

Having presented and theoretically discussed the characteristic and functions of both types of intermediaries, the following section present and discuss the factors that were identified influencing the functions of intermediaries along the four stages of the technology transfer process.

**Table 7-4: Functions of the two agents along the four stages of the transfer process**

Transfer stages	Agents	
	Non-specialized <i>Support the transfer of <u>similar</u> technologies</i>	Specialized <i>Support the transfer of <u>specific/new</u> technologies</i>
Demand articulation	<ul style="list-style-type: none"> <li>• Stimulate demand for technologies – technology push</li> <li>• Develop a repository system for the different internal demands and external suppliers</li> </ul>	<ul style="list-style-type: none"> <li>• Stimulate demands for specific technologies – technology push</li> <li>• Develop a repository system for the different internal demands and external suppliers</li> </ul>
Market scanning	<ul style="list-style-type: none"> <li>• Identify technological options as per the specifications of users</li> <li>• Enhance accessibility of users of users and facilitate communication with suppliers – linkage functions</li> <li>• Aware users of legal, financial and other needs of external suppliers</li> <li>• Negotiate prices, services, and rights of technologies on behalf of users</li> </ul>	<ul style="list-style-type: none"> <li>• Identify technological options as per the specifications of users</li> <li>• Diffuse and process information to support the adoption decision</li> <li>• Assist in evaluating various options of technologies</li> <li>• Enhance accessibility of users and facilitate communication with specialized suppliers – linkage functions</li> <li>• Aware users of legal, financial and other needs of external suppliers</li> <li>• Negotiate prices, services, and rights of technologies on behalf of users</li> </ul>
Acquisition	<ul style="list-style-type: none"> <li>• Develop the transfer agreement</li> <li>• Perform the logistical tasks to import technologies</li> </ul>	<ul style="list-style-type: none"> <li>• Develop the transfer agreement</li> <li>• Perform the logistical tasks to import technologies</li> <li>• Test, diagnose, analyse, and inspect technologies</li> </ul>
Diffusion and utilization	<ul style="list-style-type: none"> <li>• Conduct regular maintenance or train users to do it</li> </ul>	<ul style="list-style-type: none"> <li>• Identify the different functions of technologies</li> <li>• Train users into effective use and maintenance of technologies</li> <li>• Demonstrate the operation of technologies</li> </ul>



#### ***7.4 FACTORS INFLUENCING THE FUNCTIONS OF INTERMEDIARIES***

The previous sections presented the main characteristics and the functions identified for consultants and agents along the five stages of the transfer process. The empirical data analysis revealed a set of five factors influencing intermediaries' functions along the transfer process. These are the proximity (geographical and cognitive), technical specialization of intermediaries, characteristics of technologies (tacit, complex, newness), capability of users (absorptive capacity), and the corporate technology strategy of users. These five factors are summarized and presented in Tables 7-5, 7-6, and 7-7, and discussed in the subsequent sections. The tables also presented quotes of different participants, which support the influences of the different factors.

Table 7-5: The Influences of The Four Factors on the Functions of Consultants: Factors From the Conceptual Framework

	<b>Consultants</b>				
<b>Factors</b>	<b>ALPHA</b>			<b>BETA</b>	
	<i>General</i>	<i>Specialized</i>	<i>University</i>	<i>General</i>	<i>Specialized</i>
<b>Geographical proximity</b>	Their easy access (closeness) offers us a various support whenever needed	The spatial isolation does not hinder knowledge transfer or learning	The spatial closeness encourages communications	Their easy access (closeness) enriches their knowledge about the context of the industry	The spatial isolation does not hinder knowledge transfer or learning
<b>Cognitive proximity</b>	The common language and experience develops a base for communication	The lack of context knowledge hinders their ability to adapt technologies to specific contexts of different users	The lack of industrial exposure and lack of common language limits their involvement	Their close interaction with the industry locked their knowledge to that already diffused (similar to existing)	The similar views on the industry facilitate knowledge transfer
<b>Specialization</b> • Technological domain • Industry-specific	The lack of focus on a specific industry or domain limited their ability to transfer new technologies	Specialization enhances their new input contributions	The lack of industrial knowledge limits their customization to specific needs	They transfer tacit and complex technologies but are less involved in transferring new technologies	Their focus on a specific area enhances their ability to continuously produce new technologies or identify new applications
<b>Characteristics of technology</b> • Tacit & complex, new/novel	Prior knowledge enhances their knowledge processing	Specialization and R&D activities enhances their new knowledge diffusion	Specialization enhances their new knowledge production through R&D	The prior knowledge enables them to simplify and transfer multifunctional technologies	They are our key source for new technologies and techniques
<b>Capability of users</b> • Prior knowledge	We managed to reduce the effect of the agency powers practised by some intermediaries and enhance their willingness to diffuse information			Prior knowledge helps us monitor the quality of functions performed by different intermediaries.	

Table 7-6: Factors Influencing the Functions of Agents: Factors From the Conceptual Framework

	Agents			
Factor	ALPHA		BETA	
	<i>Specialized</i>	<i>Non-specialized</i>	<i>Non-specialized</i>	<i>Specialized</i>
<b>Geographical proximity</b>	Being away made them lack context specific knowledge	Close location does not enhance their functions along the process. They are not involved in prior and post access to external technologies		They assess options but are less capable of advising on a specific option
<b>Cognitive proximity</b>	The lack of industrial work experience or context specific knowledge hinders their knowledge processing capability - communication and articulation and their ability to adapt external technologies to specific needs			
<b>Specialization</b> Technological domain Industry-specific	It enhances their ability to analyse technologies or systems within their domains	NA	NA	Their focus allows them to bring new technologies or applications
<b>Characteristics of technology</b> • Tacit, complex, new/novel	Specialization increases their new knowledge production	The lack of sufficient prior knowledge about technologies being transferred made them capable of transferring codified knowledge but less capable of transferring tacit, complex or new		They are capable of analysing systems of novel features
<b>Capability of users</b> • Prior knowledge	We managed to reduce the effect of the agency powers practised by some intermediaries and enhance their willingness to diffuse information		Our capabilities determine the functions required and the quality of those functions.	

Table 7-7: The Emerging Influential Factor: Corporate Strategy

	<b>ALPHA</b>	<b>BETA</b>
<b>Corporate technology strategy</b>	<ul style="list-style-type: none"> <li>• <i>Their [intermediaries] capability evolved in response to the strategic objectives defined on the technology strategy.</i></li> <li>• <i>The strategy can act as a market regulator for actors involved in the technology transfer market</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>The strategy influences the allocation of resources for goals of learning and selection of the suppliers</i></li> <li>• </li> </ul>

\* The above three tables presents quotations from the respondents on the influence of the five factors on the functions of intermediaries.

#### **7.4.1 PROXIMITY (COGNITIVE AND GEOGRAPHICAL)**

The empirical findings established that proximity (geographical and cognitive) between intermediaries and users influences the functions that intermediaries perform along the transfer process, which, in turn, influences firms' learning. Proximity influences how intermediaries learn about users' specific needs and contexts, and importantly has an influence on how intermediaries communicate and diffuse external technologies to users.

The empirical evidence indicated that when intermediaries and users are in too close or too distant proximity, it generates negative influences on technology transfer and learning through intermediaries. The too close proximity generates a lock-in effect that makes intermediaries become part of the users' environment, which, in turn, hinders the ability of intermediaries to contribute new input or support the transfer of new technologies. This observation has been also reported in other studies on technology intermediaries (Boschma, 2005; Torre, 2008; Woerter, 2012). In contrast, a lack of proximity creates a communication gap through cognitive or geographical dimensions, which also negatively influences the technology transfer (*ibid*).

In addition, the empirical evidence suggested that cognitive proximity has more influence on functions of intermediaries than geographical proximity. Geographical closeness, although helpful for technology transfer, was found not sufficient. The geographical closeness of local industrial consultants to local firms has made them gain understanding of user specific contexts and demands. However, this proximity has less impact on the functions undertaken by university consultants or local agents because of the lack of cognitive proximity with local users, such as a lack of shared language, knowledge or understanding to the industry.

These findings offer a valid explanation for results of previous studies that found agents in form of technology transfer offices are less involved in the actual transfer of technologies between universities and industries despite they are in a close geographical proximity. For instance, Shohet and Prevezer (1996) found technology transfer agents though they operate within the same transfer system

yet they do not help users in articulating demands or adapting external technologies.. Likewise, agents that operate between suppliers and users across two different technology transfer systems were also found less involved along the different stages of the transfer process (Li-Ying, 2012). According to the empirical evidence of this study, the lack of cognitive proximity between agents and users is one of the primary reasons that limit the capability of agents to transfer technologies between suppliers and users, and their role is limited mainly to scanning and linkage functions.

In contrast to agents, as local consultants are often retired engineers from the industry, they possess industry and context specific knowledge that positions them in cognitive proximity to users. This proximity was initially enhanced by their geographical closeness that allowed them to work in the industry and accumulate a common language and knowledge base. This enabled consultants to learn about the specific demands and applications of local users, and, hence, to be able to translate external knowledge at a level that could be understood by different users, through the use of the common language. This finding agrees and supports findings from previous studies on the influence of the cognitive proximity on consultants' roles during technology transfer. For instance, in the case of the manufacturing sector, Bessant and Rush (1995) highlighted consultants who were previously industrialists, support their clients on different functions along the entire transfer process.

However, although close proximity enhanced the functions of local consultants, it generated a negative side effect with too much closeness and not enough broad experience inhibiting the intermediaries' effectiveness. Being too close to users limits the sources of knowledge and experiences that an intermediary can access, which in turn constrains what they can do. For example, some local consultants and local users were so close that the former became part of the latter's knowledge, culture and capability network, which reduced their openness to external, non-local systems. In such circumstances, local consultants can become locked-in within the same experiences of the users and fail to provide new knowledge or insights (Boschma, 2005; Woerter, 2012) and less able to support

the transfer of new technologies or experiences that vary from the local experiences.

In addition, the modest ability of local intermediaries to support users in transferring new technologies was also attributed to a lack of R&D activities, which are needed to generate new knowledge (Cohen and Levinthal, 1990), and for producing an active learning system (Viotti, 2002). Consequently, it can be argued that an intermediary who is too close and lacking R&D can be less able to drive innovation and advanced learning in the sector. Although they can support the development of operations and maintenance capability, their limited knowledge and lack of R&D mean that their capability to generate improvement or innovation capability is limited, as it has been found and highlighted in other studies (Mowery and Oxley, 1995; Viotti, 2002).

On the other hand, the study also found that the geographical distance does not always have a negative influence on intermediaries' functions if there is cognitive proximity. For instance, specialized consultants who are not in geographical proximity with local users can still significantly contribute to local users' learning through transferring new knowledge to local contexts. Therefore, the lack of geographical proximity between specialized consultants and local users can diversify their sources of knowledge and experience, which in turn has enabled them to transfer new and diverse inputs to the local users (Woerter, 2012). For instance, they help in identifying new functions of existing technologies or bringing radically new technologies/techniques to the local contexts.

However, although specialized consultants are geographically away from BETA, being in alliance with BETA made them aware of the firm's contexts of technology applications. Thus, they complement the lack of BETA's internal capability and contribute to adapting new technologies to BETA's specific contexts. In contrast, as specialized consultants are not in alliance with ALPHA, the adaptation and changes associated with new technologies were implemented through collaboration between the specialized and local consultants, or between specialized consultants and ALPHA's experienced personnel. With the case of ALPHA, local consultants played the role of interpreter between specialized consultants and users.

Similarly, while there is a cognitive gap between local agents and users, agents are in a cognitive proximity with other agents or suppliers of technologies. This closeness has raised the awareness of local agents about various aspects of technology market; not least the legal and administrative requirements needed for international technology transfer. Consequently, while they linked users with suppliers, they also advised local users on those requirements, which are essential to initiate a transfer project.

There is also a noticeable communication gap between the specialized agents and local users. Although these agents are often knowledgeable about the technologies they transfer, they lack the industry and context specific knowledge required for local adaptation. While they are knowledgeable about the various functions of technologies being transferred, their lack of industry-specific knowledge meant they were less capable of advising on a specific technology, or customizing technologies to the specific context of the industry.

In conclusion, the empirical findings of this study revealed that both too close or lack of proximity negatively influences the functions of intermediaries. Too close proximity lock-in the experiences and knowledge of intermediaries, as it has been also found in other studies (Boschma, 2005; Torre and Gilly, 2000), while lack of proximity complicates communications and knowledge transfer (Boschma, 2005; Woerter, 2012). Moreover, the cognitive dimension of proximity was found more influential than geographical proximity, as the negative influences of the lack of geographical proximity can be counter-balanced by the cognitive proximity but not the opposite. New communication tools, such as e-mails or other forms of teleconference media was found to substitute for geographical proximity, which substantiates previous findings (Boschma, 2005; Rebolledo and Nollet, 2011). In contrast, a cognitive gap is only bridged by raising the level of technological capability of the interacting sources and recipients of technologies (Cohen and Levinthal, 1990; Woerter, 2012).

Based on this discussion and findings it is possible to argue that proximity does influence the different functions of different intermediaries along the technology

transfer process. These findings support the initial thoughts of the conceptual framework used in this research.

#### **7.4.2 SPECIALIZATION OF INTERMEDIARY**

The empirical evidence clearly indicated that specialization of intermediaries has a direct influence on their functions during the transfer process, and, consequently, on recipients' technological learning. Previous studies have suggested that each sector requires an intermediary who specializes in that sector in order to support its development (Intarakumnerd and Chaoroenporn, 2013). However, it is still not entirely clear how specialization (or the lack of it) of intermediaries influences the transfer process in a sector, and hence the sector's technological development.

Respondents from ALPHA and BETA intensively mentioned the significance of intermediaries' specialization (prior experience) for how they carry out their different functions. This study discovered that an intermediary specializes in the sector or in a technological domain typically possesses rich prior knowledge (absorptive capacity) about their area and this accumulates in a path dependent way. Similarly, the lack of specialization weakens the prior knowledge of intermediaries about sectors or their technological domains.

Little research has been conducted on the influence of the specialization on the functions of intermediaries or producers. Consequently, this study is an early attempt to discover how it might influence the different functions. While previous studies have examined factors influencing the functions of suppliers along the transfer process, they have not paid adequate attention to the prior knowledge about the technologies being transferred (e.g. Cyhn, 2002; Minbaeva, 2007; Mu *et al.*, 2010). This is mainly due to the implicit assumption, widely adopted by previous studies, that suppliers are the original producers who are therefore presumed to be specialized and knowledgeable about the technologies being transferred. Accordingly, studies on the technology transfer capacity of suppliers consider only the capability of suppliers to simplify, articulate and communicate knowledge to users (Minbaeva, 2007; Mu *et al.*, 2010; Sazali and Rose, 2011), but not the prior knowledge.



When suppliers are intermediaries, it cannot be presumed that they are knowledgeable about either the technologies being transferred or the industries to which they are supplying. Previous studies on technology intermediaries have not adequately questioned what actually develops the capability of intermediaries to transfer a technology that the intermediaries did not produce themselves. The evidence of this study has identified that, for effective technology transfer through intermediaries, they have dual roles. From one side they are recipients of technologies when they acquire technologies from original suppliers. For this role, they require adequate absorptive capacity (prior knowledge) to absorb technologies from external sources (i.e. the original producers) (Cohen and Levinthal, 1990). From the other side, they are suppliers when they transfer technologies to end-users. For this role, intermediaries require adequate disseminative capacity, the capacity to articulate and communicate technologies at a level understood by different users (Hamel, 1991; Minbaeva and Michailova, 2004).

Accordingly, the technology transfer capacity of intermediaries is not only a function of their disseminative function, which is the case for the producers, but also a function of their absorptive capability (prior knowledge) about the technologies being transferred.

Consequently, the specialization of intermediaries, as reflected by the prior knowledge, adds a new dimension to the technology transfer capacity of suppliers when they are intermediaries. Specialization (accumulated knowledge) includes the ability to identify technologies and their sources, ability to select technologies for the transfer, and learning about technical specifications and functionalities of technologies. In addition, it also includes knowledge about systems where technologies will be employed.

The empirical evidence in this study discovered that not all intermediaries assume the dual roles of recipient and supplier, and thus negatively influence the diffusion of technologies and learning of users. A lack of prior knowledge weakens the absorptive capacity of intermediaries, while a lack of disseminative capacity obstructs the diffusion of technologies. This finding agrees with findings of the

absorptive capacity (Cohen and Levinthal, 1990); and disseminative capacity (Minbaeva and Michailova, 2004; Szulanski, 1996).

For instance, as a result of the prior knowledge of industrial consultants, they were reported to be involved in diagnosing and defining the problems facing the industry, identifying opportunities, suggesting solutions, assessing and selecting options, and ensuring the compatibility and adaptability of external technologies with internal systems. Nonetheless, respondents emphasized that consultants were able to perform these functions not only due to specialization but also enhanced by their proximity to users.

In contrast to industrial consultants, local agents operate across various technological domains and deal with different sectors, thus they were described as possessing modest prior knowledge about any particular domain or sector. This lack of specialization has negatively influenced their absorptive capacity, which in turn hindered their ability to absorb technologies from their sources. Consequently, they were found less effective for transferring technologies with the associated technological knowledge. That is why most agents, mostly due to lack of specialization, were described as transferring technologies as black boxes without adequately absorbing knowledge associated with technologies. Although agents help users in identifying a wide range of options, they seldom help in the assessment of those options or the adaptation.

Importantly, respondents from both firms agreed that users perceive specialized intermediaries as credible and reliable sources for valuable and new knowledge. The more intermediaries are specialized, the more credible and reliable they are perceived. Users tend to accept the suggestions and judgements of specialized and knowledgeable intermediaries and take their opinion at face value (Bessant and Rush, 1995). This result agrees with previous finding the highlighted that, perceiving suppliers knowledgeable source for knowledge was a found among the factors that influence the effectiveness of technology transfer processes (Szulanski, 2000).

As prior knowledge (absorptive capacity) of local intermediaries (industrial consultants) has been accumulated mostly through learning-by-using of

technologies available with local users, their transfer capacity is limited to transferring similar technologies to those already used by local users. This is the lock-in effect of intermediaries as a result of being too close to local users, that was highlighted in other studies (Boschma, 2005). In contrast, specialized consultants do not only develop their prior knowledge (absorptive capacity) through learning-by-using but also through their internal R&D activities. Consequently, they are continuously transferring new knowledge and new input to local users.

According to respondents, ALPHA and BETA access and transfer new technologies through specialized consultants. The specialization of specialized intermediaries together with their R&D activities justifies their involvement with both ALPHA and BETA, as they always provide new technologies or new applications. This involvement suggests that, with the presence of specialized intermediaries in the sector, local firms in the oil and gas sector do not necessarily need to do as much internal R&D activity in order to generate new technologies as had been initially thought. Instead, they can access and rely on specialized intermediaries as credible sources of new knowledge. The issue remains with the mechanism of developing or localising specialised suppliers in developing countries that possess weak research infrastructure. This finding agrees with Pavitt's (1984) taxonomy of sectoral patterns for technical change that identified specialized suppliers as the drivers of innovation in the oil and gas industry.

By examining and identifying the influences of specialization on functions of consultants and agents within the two firms, this study has redefined the technology transfer capacity of suppliers to include the prior knowledge of intermediaries about technologies being transferred and the industry itself. Accordingly, the technology transfer capacity of intermediaries can be defined as "the prior knowledge of intermediaries about technologies being transferred, and the ability to articulate and communicate those technologies to a level understood by different respondents".

The above empirical evidence confirmed the initial suggestion of the conceptual framework developed for this study, that the specialization of intermediaries influences the functions of intermediaries. This specialisation is crucial especially

when technologies are being transferred through multiple intermediaries who might belong to different backgrounds. This evidence supports ideas in previous studies of technology intermediaries that are not explicitly stated about specialization. This includes Leonard-Barton's (1984) indirect point that the previous experience made diffusion intermediaries capable of identifying, assessing, and selecting technologies for less capable users in the case of the health sector. Therefore, it is possible to argue that specialization of intermediaries does influence their functions along the transfer process.

### **7.4.3 CHARACTERISTICS OF TECHNOLOGY**

The empirical findings on the influences of this factor on the functions of intermediaries confirmed the initial suggestion of the conceptual framework. The three main characteristics of technologies that might influence the functions of intermediaries are the tacitness, technical complexity and the novelty of technologies. Several researchers have expressed their concern about the influences of these characteristics on technology transfer and learning when technologies are transferred from their original sources (see e.g. Cyhn, 2002; Grindley and Teece, 1997; Kogut and Zander, 1993; Schulz, 2001; Simonin, 1999; Steensma, 1996). The findings of this study recognize that the influences of these characteristics on inter-firm technology transfer are even greater when suppliers are intermediaries, who might not be knowledgeable about technologies being transferred.

Tacitness and technical complexity influence the capability of intermediaries to absorb, simplify, translate, articulate and communicate technologies to local users. The transfer of complex technologies requires a diversity of skills (Steensma, 1996), that this study showed not all intermediaries possess. For instance, respondents confirmed that intermediaries who participate in analysing or simplifying a field complex monitoring system are mostly those who have previously worked with such systems and are knowledgeable about its various functions. Similarly, adapting such technologies into internal systems requires knowledge about both the different components of the technologies and the internal system, so adaptability can be assured. Consequently, agents may not be capable of transferring such systems.

Technology transfer from external sources requires knowledge about different aspects of technologies including the specifications, operating conditions; functionalities, connectivity and compatibility of different functions, in addition to knowledge about the internal system where external technologies will be installed. This means that proximity and prior knowledge about technologies being transferred are essential in the transfer of complex technologies. Consequently, local industrial consultants are often involved in the transfer of complex technologies that are similar to existing technologies, but agents were found to be less involved.

The newness (novelty) of technologies is the most cited characteristic that significantly influences technology transfer through intermediaries. ALPHA and BETA consider a technology new if it performs different functions from those performed by existing technologies, or if it will operate in different contexts and operating conditions from those of existing technologies, or if it requires the development of new skills and capabilities. According to several participants, the great influence of newness on functions of intermediaries is mainly due to the change it might introduce to the existing system or the new skills it may require for its transfer. These two influences of newness of technologies on transferability have been also highlighted in previous studies (e.g. Schulz, 2001; Steensma, 1996).

New technologies were described as containing several elements that are new to the firm such as new functions, specifications, skills, and infrastructure. When the specifications and functionalities of the technology being transferred differ from the existing, the transfer process might involve the development of new skills and capabilities, or even unique capabilities. The skills and capabilities developed based on old technologies in many cases became out-dated or obsolete, and might not meet the technical specifications of the new technologies (Schulz, 2001). Accordingly, the newness of technologies pushes intermediaries and local users to develop a new set of skills and capabilities to meet the technical needs of the new technologies.

Newness also influences the functions of intermediaries through the changes in existing systems that sometimes accompany the transfer of new technologies.

These changes could include reconfiguring the specifications of the old system, changes in some physical connection (wiring) in order to become compatible with new functionalities, and replacing some hardware for the new functions. According to engineers, in some cases the change might even involve relocation of the entire system. For instance, replacing old manual technologies with smart technologies requires several changes such as changes to the wiring system, changes to system configuration, and changes in the way the system interacts with other systems.

Due to these possible changes, transferring new technologies requires knowledge about not only the external technologies but also the internal system (old technologies) in order to ensure the match and adaptability between the old and new technologies.

Due to the specialization and the R&D activities of specialized consultants, they were described as the principle intermediary for the transfer of new technologies or the identification of new functions of existing technologies. They bring new knowledge and identify new applications for existing technologies. In contrast, local industrial consultants are locked-in to certain types of technologies that have been widely used with local users, thus they are less capable of supporting the transfer of technologies if they differ from the existing technologies. Consequently, local intermediaries are not prepared to support local innovation when innovation is understood in terms of introducing new functions or new technologies into the local contexts.

However, specialized intermediaries often lack knowledge about the specific local contexts where the technologies will be employed. Thus the transfer of new technologies was described as involving collaboration between specialized and local intermediaries where the knowledge of each consultant complements each other. Whereas specialized intermediaries perform the identification, assessment of various new technologies, and communication and articulation, local intermediaries act more like interpreters involved in the adaptation and exploitation with the support of the specialized consultants.

The above empirical evidence confirms the initial suggestion that characteristics of technologies do influence the functions of intermediaries. This finding also

confirms previous findings that implicitly highlight that the characteristics of technologies, such as tacitness and complexity, influence the diffusion capability of intermediaries (Leonard-Barton, 1990; Shohet and Prevezer, 1996). The empirical evidence highlights that the lack of intermediaries' capability such as agents to diffuse complex technologies is due to the fact that the transfer of complex technologies draws upon multiple kinds of interrelated competencies (Minbaeva, 2007) that not all intermediaries possess.

This study found the novelty or newness of technologies is the most influential characteristic of technologies, as it requires special skills and special absorptive capacity (Cohen and Levinthal, 1990) for its transfer. In addition it might involve changes to existing systems. Importantly, it requires specialized intermediaries with wider exposure to different experiences other than the local experience.

Therefore, based on the presented evidence, it can be argued that the characteristics of technologies influence the functions of intermediaries along the transfer process, and determine what type of intermediaries can transfer what type of technologies, generating a so-called a division of labour in the transfer process among different intermediaries. These findings are summarized in Table 7-8.

**Table 7-8: Characteristics of Intermediaries and Characteristics of Technologies they can Transfer**

Technology	Novelty	
	High (new to existing)	Low (similar to existing)
<b>Tacit/ Complex</b>	Specialization in the technological domain to understand its novelty Close proximity to users to support the communication, adaptation and diffusion <ul style="list-style-type: none"> <li>• <i>Specialized industrial consultants for the transfer</i></li> <li>• <i>Combination efforts between specialised &amp; General industrial consultants for the adaptation</i></li> </ul>	Industrial experience to learn about the existing technologies Close proximity to users to support the communication, adaptation and diffusion <ul style="list-style-type: none"> <li>• <b>General industrial consultants</b></li> </ul>
<b>Codified/ Simple</b>	Specialization in the technological domain to understand its novelty <ul style="list-style-type: none"> <li>• <b>Specialized agents</b></li> <li>• <b>General industrial consultants for the adaptation</b></li> </ul>	Certain level of absorptive and disseminative capacity from users and suppliers <ul style="list-style-type: none"> <li>• <b>General agents</b></li> </ul>

#### 7.4.4 USERS OF TECHNOLOGIES

This is the last of the four factors that were originally suggested in the conceptual framework of this study. Respondents from ALPHA and BETA emphasized that users of technologies influence the function of intermediaries along the transfer process through their internal absorptive capacity (prior knowledge about the technologies) and through their technology strategy.

- **ABSORPTIVE CAPACITY (PRIOR KNOWLEDGE ABOUT TECHNOLOGIES)**

Previous studies have examined and identified the influences of absorptive capacity on firms' internal learning through inward technology transfer (Cohen and Levinthal, 1990; Kim, 1999). However, there is far less research on how absorptive capacity might influence the function of the source of technologies, particularly in relation to intermediaries.

Respondents from ALPHA and BETA frequently cited the influences of absorptive capacity on functions of intermediaries. Absorptive capacity, in terms of prior related knowledge, influences the intermediaries' functions at different stages of the transfer process by enhancing the involvement of users in the process as it encourages them to become active rather than passive recipients of technologies from external sources.

Active recipients that possess adequate prior knowledge about the nature of technologies being transferred, for instance, participate in the demand articulation stage, define the characteristics of external technologies, and assess the various options to select the best option without the strong influence from intermediaries to adopt a particular option. The adoption decision with active recipients is informed by processing the information diffused by intermediaries. Prior knowledge enables users to decide on and select a competent intermediary who will give support for a particular technology transfer project. In this function, prior knowledge plays the role of a quality assurance function through which users ensure the quality of an intermediary and their different functions along the transfer process. As a result of prior knowledge, active users determine and specify



the functions of intermediaries along the process. The active involvement of recipient firms along the technology transfer process was highlighted as a direct influence on technological learning (Viotti, 2002).

On the other hand, passive recipients are those with low prior knowledge about technologies being transferred, thus have less involvement along the transfer stages while intermediaries dominate most functions. With passive recipients, intermediaries choose and select technologies for users and directly influence the adoption decision, as the same result was highlighted in previous studies (Leonard-Barton, 1984). Moreover, intermediaries screen the level of information that is diffused to passive recipients, which negatively influences the firm's learning and technology development (*ibid*).

Users also noticed that intermediaries made use of their agency power and limited the level of knowledge transfer when dealing with users with low prior knowledge, so they protect their market position and keep users relying on their services. Leonard-Barton (1984) indirectly pointed to the agency power of diffusion intermediaries when dealing with less-capable recipients. The diffusion intermediaries screen and control the level of information diffused when dealing with less knowledgeable users.

Respondents highlighted that their prior knowledge about the technologies being transferred motivates intermediaries to be more actively involved in the transfer process and diffuse more information to users. For instance, industrial consultants and specialized agents were noticed to diffuse more information and actively interact with users along the process when the latter are knowledgeable. This finding supports previous findings about the influence of prior knowledge for learning in the oil and gas sector. For instance, Dantas and Bell (2011) found prior knowledge and technological capability were a condition for users to join and get embedded in a knowledge network through which users can learn and develop advanced technological capability (Dantas and Bell, 2011).

Nonetheless, since most firms with weak internal R&D activities, such as ALPHA and BETA, develop their prior knowledge mainly as a result of learning by using technologies (Kim, 1999; Malerba, 1992), prior knowledge is often limited to

technologies that are already used within the firms. Thus, they are actively involved in the transfer process of technologies that are similar to existing. When the transfer process is about the new technologies that users have not used before, users lack prior knowledge and thus become more passive recipients at the beginning and only move to become more active as knowledge is accumulated.

To reduce the influence of the agency power of many intermediaries, both firms turned to specialized industrial consultants to complement the lack of prior knowledge in the transfer of new technologies. This enhances the position of industrial consultants as a reliable and credible source of knowledge and technical support.

Therefore, based on the above empirical evidence, it is possible to argue that prior knowledge influences the functions of intermediaries in diffusing more information about technologies, and, in turn, the firm's learning. Previous studies on the influences of absorptive capacity were mainly limited to examining its influence on the firm's ability to learn from external sources. This study identified a new function for absorptive capacity, which is the quality assurance for the functions of intermediaries along the transfer process. This function of absorptive capacity has not received adequate attention in previous studies that examined the firm's absorptive capacity in developing countries (e.g. Kim, 1999; Kumar *et al.*, 1999; Sazali and Rose, 2011; Viotti, 2002).

Therefore, prior knowledge made users active recipients in the transfer process and made the technology transfer follow the demand-pull approach, which has been highlighted as crucial in an effective transfer process and technological learning (Andersson, 2009; Bessant and Rush, 1995; Szulanski, 1996). Users' lack of prior knowledge made them passive recipients to external technologies (Viotti, 2003), and increased the level of agency power of intermediaries so that they could control the entire transfer process (Leonard-Barton, 1984).

#### **7.4.5 USER FIRM'S TECHNOLOGY STRATEGY**

The second highly emphasized characteristic of users, through which they influence intermediaries' functions, is the firm's technology strategy. This factor

was not initially suggested among the factors to be examined during the fieldwork of this study. Surprisingly, during various conversations, respondents from ALPHA and BETA placed significant emphasis on the influence of this factor on intermediaries' functions along the transfer process. Respondents from both firms emphasized that a lack of strategic commitment to technological learning as one of the main reasons for the failure of most industrial projects. During the fieldwork for this study it was difficult to access the technology strategy of both firms - ALPHA and BETA; however, it was possible to learn about the significance of technological learning as a strategic objective through various respondents.

There is ample research that has examined the influence of technology strategy on the firm's internal learning and competitiveness (e.g. Dodgson, 1991; Nonaka and Takeuchi, 1995; Simonin, 2004). For instance, Nonaka and Takeuchi (1995) argued that learning through knowledge conversion from codified to tacit is driven by organizational intention that is reflected in the firm's strategy. The strategy directly influences the allocation of resources for learning (Simonin, 2004). For instance, Bell and Pavitt (1995) and Ngoc Ca (1999) both argued that technological learning is only achieved when learning is made a strategic objective to be achieved through the transfer process. However, there is a dearth in research that examined how strategy might influence the functions undertaken by suppliers of technologies during the transfer process.

The empirical findings of this study found that a firm's technology strategy influences intermediaries through raising the level of their involvement in firm's learning to support the achievement of learning as a strategic objective. Users raise the level of involvement by introducing a set of technical criteria that intermediaries should meet in order to support user's learning. These proposed criteria are expected to drive the development of capability and skills of intermediaries to perform given functions. Consequently, the strategy can act as a market regulator and a quality control device for the functions of intermediaries by ensuring intermediaries involved with users meet certain level of technical standards.

The quality assurance function of the strategy is crucial for firms that rely heavily on intermediaries to gain access to external technologies in order to ensure the quality of technology transfer partners. It has been already highlighted by other studies that, due to the expansion in the technology transfer market, different intermediaries have emerged who do not always possess an adequate level of capability to support effective technology transfer (Bessant and Rush, 1995). The technology transfer market in Oman is not an exception, and is one in which many intermediaries have emerged, while their technical quality is not adequately known. Where there is a lack of market regulation for the technical capability of suppliers or intermediaries, the intermediation market might suffer from low levels of capability and therefore be weak at supporting firms' learning. When the recipients' technology strategy acts as a market regulator, the quality of intermediaries is indirectly defined by the strategy.

Managers from both firms highlighted the possibility of employing a regulatory role for the strategy. For example, according to a technology manager, different markets have measures to regulate its operation and quality performance. For instance, a person intending to engage in teaching has to present certain qualifications and skills prior to being allowed to work as a teacher. In a similar trend, intermediaries operating in the technology transfer market should meet a minimum level of competency before they can be allowed to transfer external technologies. Without such measures, intermediaries tend to transfer technologies as a black box, which negatively influences the country's long-term technological development.

However, this role of strategy suggests that recipient firms possess the capability to develop their strategy, define their objects, define certain criteria to assess suppliers, and identify their technology transfer needs. In the absence of such capability, users tend to rely on trustworthy consultants to support them in the selection of other intermediaries.

To date, there is almost no mention in previous studies of the influence of "technology strategy" on the function of suppliers (producers or intermediaries), or its role in regulating the market for quality purposes. However, previous studies

on technology transfer and technological learning have identified the influences of technology strategy on the firm's internal efforts for learning, but little has been said on its influence on the suppliers (see e.g. Cyhn, 2002; Ngoc Ca, 1999; Steensma, 1996).

Technological learning literature highlighted that strategy helps in identifying the type of technology for the transfer process, the sources and the channels of transfer that all influence technological learning (Steensma, 1996; Viotti, 2002). In addition, strategy also influences the allocation of resources required for learning along the transfer process. For instance, Woiceshyn and Daellenbach (2005) found that management commitments through the allocation of resources and capability development influence the integration of the external technologies with internal systems in the oil and gas industry (Woiceshyn and Daellenbach, 2005).

The above empirical evidence confirms that technology strategy plays a significant role in technology transfer and learning through intermediaries by enhancing the technical level of intermediaries involved with users. The regulatory role of the strategy is an extra role for the strategy, in addition to its role in resources allocation for technological learning.

### ***7.5 TECHNOLOGY TRANSFER THROUGH INTERMEDIARIES: A MODIFIED CONCEPTUAL FRAMEWORK***

One of the key objectives of this study is to develop a conceptual framework for the key factors that influence technology transfer and technological learning through intermediaries. Based on the evidence gained from the cross-case analysis, the original conceptual framework (Figure 3-1) has been modified to include corporate technology strategy as an additional factor that has significant influence on intermediaries' functions. The new framework is illustrated in Figure 7-1 below. This modified framework is intended to provide a more holistic understanding of what factors influence intermediaries' functions during the transfer process. The framework illustrates that, while technologies are transferred from original sources to end users through either consultants of technology or agents, a set of five factors influence the effective technology

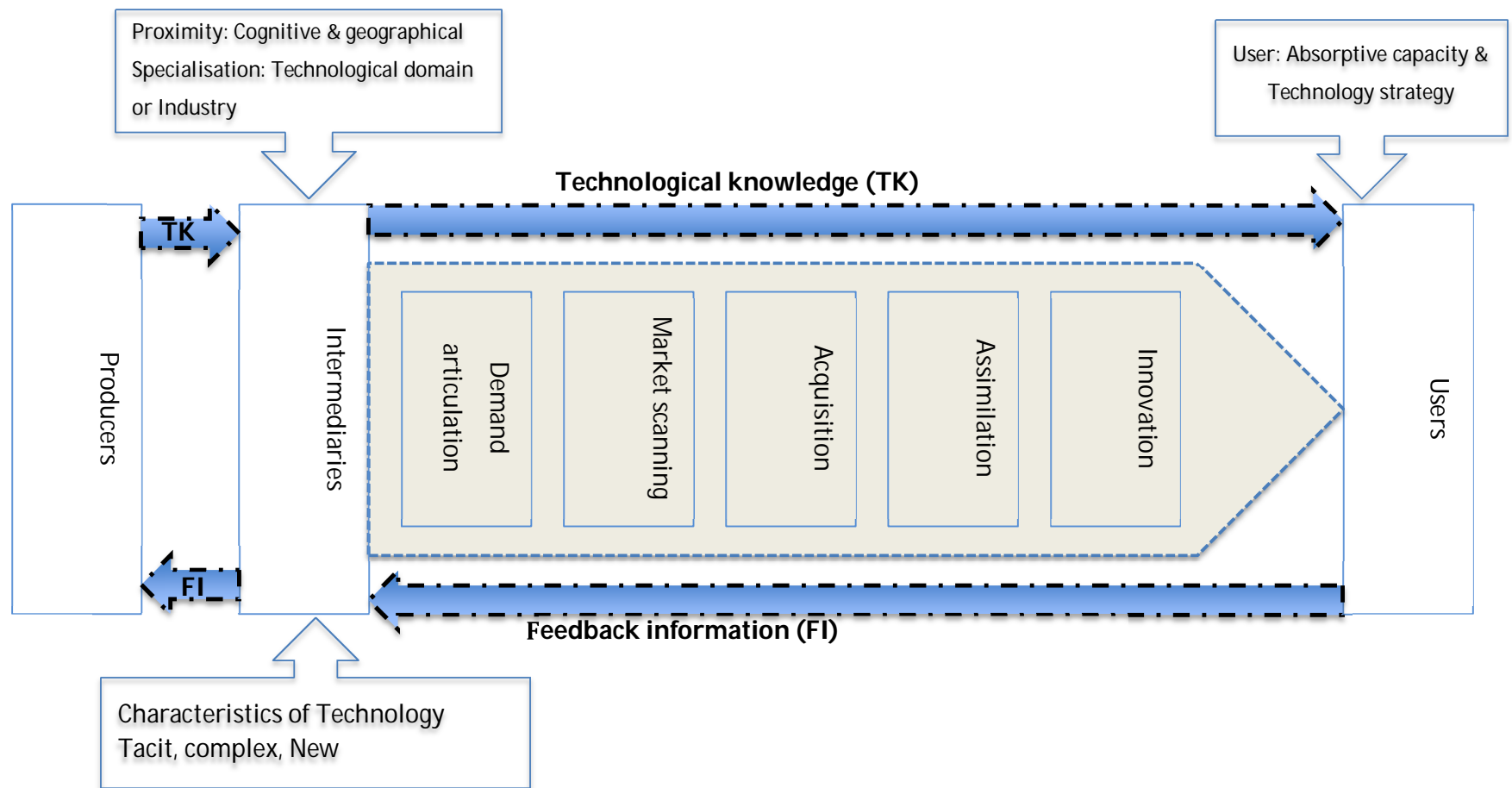
transfer. These factors are the proximity of intermediaries with respect to users including the geographical and cognitive dimensions, specialization of intermediaries in terms of sector-specific or technology-specific, characteristics of technologies including tacitness, complexity and newness, and finally the user's absorptive capacity, and user firm's technology strategy.

The empirical findings of this study support the findings of some previous studies and provide explanations for earlier findings that were left without adequate explanation. For instance, previous studies have identified that technology agents are mainly involved in linking users with suppliers, but have not explained why they tend to be limited to this function. This study suggests that these five factors, or one of them, might be the reason for the limited functions of agents.

This study identified three different types of consultants involved in technology transfer in the local oil and gas sector. Two possess industrial experience and belong to the users' community of practice. They offer either a general service to the industry (general industrial consultants) or are specialized in a specific area within the industry (specialized industrial consultants). Both share a common understanding of the industry with users, and are in cognitive proximity. The third type is the university-based researcher with research interests in the industry. Although they are knowledgeable about the science of the industry, they do not possess adequate industrial experience and hence do not always have a similar understanding with users. As such there is cognitive gap between them and the users.

Specialization and proximity of the three consultants were found to determine the functions that they perform for users and the types of technologies they transfer. While general industrial consultants are more involved in the transfer of technologies that are similar to existing technologies, specialized consultants are more involved in the transfer of new technologies or in identifying new applications for existing technologies.

Figure 7-1 The Modified Conceptual Framework to include the Emergent Factors



On the other hand, agents are representatives of regional and global producers of technologies or other agents. The study identified two main types of agents involved in technology transfer: general technology agents and specialized technology agents. The former offers different services for different users across different sectors or industries. The latter offers a specific service, but in many cases serves different users across different industries. Both agents often lack adequate real industrial experience, and this can mean agents lack cognitive proximity with users. Specialization and proximity of the two agents were found to determine the functions that they perform for users and the types of technologies they transfer.

Proximity to users was found to influence the ability of intermediaries to learn about the specific needs of different users, the context of applications for external technologies, and to be able to communicate and understand the communication of users. The empirical evidence revealed that both too close and too distant proximity negatively influences the functions of intermediaries. Too close proximity to users leads to lock-in experience and capability of intermediaries, while too distant generates difficulty in communication and technology transfer.

The study also revealed that the influence of proximity is better understood when both dimensions, the geographical and cognitive, are examined together. Cognitive proximity was found to be more influential than geographical (spatial) proximity. While modern telecommunication tools can complement the geographical isolation, cognitive proximity cannot be complemented without bridging the capability gap between intermediaries and users.

Specialization of intermediaries (industrial or technology) was discovered to influence the accumulation and development of absorptive capacity (prior related knowledge) of intermediaries, which in turn enhanced their ability to absorb external technologies prior to diffusing them. Specialization has redefined the technology transfer capacity of intermediaries from the conventional understanding of the transfer capacity in existing studies (e.g. Easterby-Smith et al., 2008; Hamel, 1991; Minbaeva and Michailova, 2004; Park et al., 2013). Intermediaries cannot be taken as knowledgeable about technologies being



transferred. The lack of specialization reduces their absorptive and disseminative capacity, which in turn negatively influences technology absorption and diffusion. This in turn negatively influences the user's learning.

Characteristics of technologies were also found to influence the functions of intermediaries. Among the three characteristics examined, namely tacitness, complexity and newness, newness was found to be the most influential. That is mainly due to the special skills and capability required along the transfer process, in addition to the changes it might introduce on the existing system.

The absorptive capacity of users was perceived in this study from different angles in comparison to previous studies that examined its influence on firms' internal learning from external sources. This study suggested that it also influences the functions of intermediaries by making recipients more active along the transfer process and stimulate the willingness of suppliers to engage in effective technology transfer for learning. Prior knowledge (absorptive capacity) reduces the agency power of some intermediaries in controlling the level of technologies diffused to users. In addition, it also plays a function of quality assurance for the functions of intermediaries.

The last factor, and the most influential on intermediaries' functions, is the firm's technology strategy. Previous studies have examined how firm's strategy influences the firm's internal learning through resource deployment and learning efforts (e.g. Dodgson, 1991; Hamel, 1991; Simonin, 2004). The influence of strategy on suppliers' functions along the transfer process has not received adequate research so far and thus remained poorly understood. While strategy does influence firm's internal learning, it also acts as a market regulator by introducing quality control measures for intermediaries. This can have the effect of driving technological upgrading among intermediaries to meet the strategic objectives of users. The regulatory function of the strategy is crucial for firms that rely heavily on intermediaries to gain access to external technologies. This is to ensure the technological capability of external partners involved with users during the technology transfer process.

In general, this study moved beyond previous studies on technology intermediaries that often stop at mapping out intermediaries' different functions (e.g. Howells, 2006; Kilelu *et al.*, 2011), or treat intermediaries as a linking service (e.g. Li-Ying, 2012; Shohet and Prevezer, 1996). The findings of this study add to the knowledge by highlighting the different factors that influence the different functions of different intermediaries, in addition to mapping out the different functions of intermediaries in the local oil and gas sector. It provides an understanding about factors that make some intermediaries perform certain functions along the transfer process, and how that influences the recipient firm's learning.

Such knowledge about these factors is crucial, especially for firms that rely heavily on intermediaries, are isolated from the original sources of technologies, and possesses weak internal technology production capacity. Understanding the influences of these factors may well help such firms to identify when intermediaries can perform particular functions for them, and how that might influence firms' learning.

## **7.6 SUMMARY**

This chapter presented and discussed the findings from the two cases. It was based on the results gained from the within-case analysis of the two cases. This study can be considered an early attempt that examined the factors that influence the functions of intermediaries along the transfer stages. Based on an intensive literature review, the study started by suggesting four factors that might influence intermediaries' functions during the transfer process. These are the proximity, specialization of intermediaries, characteristics of technologies, and the capability of users of technologies. The evidence achieved from the analysis confirms the initial suggestion of this study. An additional influential factor emerged during data analysis, that is the corporate technology strategy.

Having theoretically discussed the empirical findings of this study with respect to existing studies, the following chapter is the conclusions chapter. It presents an overview of this study, discusses the contributions, acknowledges the limitations and offers suggestions for future research.

## 8 CONCLUSIONS

### ***8.1 INTRODUCTION***

This is the final chapter in this thesis. It presents an overview of the study and the journey of the research from problem definition through to the final results. The previous chapters presented, discussed and reflected upon the findings of the cross-case analysis, and offered a revised conceptual framework of factors influencing technology transfer through intermediaries. The presentation and discussion of the empirical evidence led to the conclusion that five factors impact intermediaries' functions during the transfer process. Their analysis suggests that industrial consultants are likely to be more effective at driving users' technological learning than technology agents.

This chapter includes four main sections in addition to a short introduction and concluding summary. The first section presents an overall summary of this research and the key findings. This is followed by a discussion of the study contributions, implications to theory and practice in Section 8.3. Section 8.4 presents the research implications and policy recommendations. Section 8.5 acknowledges the research limitations and offers directions for future research. Finally, the summary of this chapter is presented in Section 8.6.

### ***8.1 RESEARCH OVERVIEW AND MAIN FINDINGS***

This study started with the aim of identifying and examining the functions of intermediaries during the different stages of technology transfer process and factors that influence those functions. It sought further to identify how those factors might influence recipients' technological learning.

This study started with an introductory chapter that defined the main concepts, the research background and research problem within the literatures of technological learning via technology transfer and technology intermediaries. It also highlighted the main gaps in the two literatures. The literature on

technological learning within the context of developing countries does not offer adequate explanation on the influence of the emergence of technology intermediaries along the transfer process on the firm's learning. Likewise, the literature on technology intermediaries, while it mapped out the different functions of intermediaries, it doesn't provide sufficient discussion on the factors influencing the different functions of different intermediaries along the transfer process. These gaps within the two literatures deserved further investigation to provide better understanding for technology transfer for users within the developing countries. The introduction also highlighted the objectives of this research, which is to identify the functions of intermediaries along the transfer process and the factors influencing those functions and how that influence user's learning. The introductions also presented an overview about the research design, the research relevance and significance, the main findings; the chapter also offered an overview of the structure of this thesis.

Chapter 2 focused primarily on reviewing the two bodies of literature of technological learning via technology transfer and technology intermediaries in the context of developing countries. This established the theoretical background for the study and highlighted the major gaps in knowledge that deserve further scientific inquiry. The review identified the absence of previous studies that examined technology intermediaries from the perspective of technological learning framework to examine the functions of technology intermediaries. Hence, this study is leading in the combination of the two literatures (technological learning and technology intermediaries) to examine the functions of technology intermediaries in the context of user firms in developing countries.

The literature review highlighted two main gaps where this study has contributed. First, despite technological learning theory (Kim, 1980; Kim, 1999; Bell and Pavit, 1993; Cyhn, 2002; Figueiredo, 2003) focusing on learning in firms that originally lack adequate technological capability and are mostly isolated from sources of technologies, the theory did not sufficiently explain how such firms define their internal demands for external technologies, or how they identify and learn about the potential range of technologies from the market and select the most suitable options for their demands. Consequently, whether firms or their suppliers

identified and defined internal demands, or explored a range of options and how they were implemented is not adequately explained or understood. Second, as the technological learning theory via technology transfer assumes learning occurs through the direct producer-user relationships (Cyhn, 2002), the theory did not offer satisfactory answers for the influences of the emergence of technology intermediaries as new actors between producers and users along the transfer process. It remains poorly explained what factors influence the transfer process through intermediaries and how those factors might influence learning.

The literature review on technology intermediaries identified the main types and functions of different intermediaries along the innovation and technology transfer process. However, although prior studies on technology intermediaries identified the different functions of intermediaries along the various stages of technology transfer (e.g. Howells, 2006; Kilelu et al., 2011, Clarke and Ramirez, 2011), they did not explain what factors influence the different functions and therefore the learning of end users. In other words, it remained poorly understood which factors made some intermediaries perform certain functions during the transfer process, and how that might influence the recipient's learning. Moreover, previous studies on technology intermediaries list the different functions of intermediaries without explicitly highlighting the theoretical stance upon which those functions were identified. This study contributed to fill this gap and has mapped out the different functions of technology agents and consultants and identified the factors that influence their functions. This study examined -from the technological learning framework- the functions of intermediaries and the factors that influence those functions as a direct supplier along the transfer process.

Due to the exploratory nature of this study, the thesis began by presenting a conceptual framework to guide the data collection and analysis process. This was developed and explained in Chapter 3. Instead of adopting a grounded theory or pure inductive approach, existing theories and studies were used to guide the research, and a combination of inductive and deductive approaches were employed to obtain results. Building on previous studies on technological learning and technology intermediaries, the conceptual framework suggested four interrelated factors that influence intermediaries' functions during the transfer

process. These are the proximity, specialization of intermediaries, characteristics of technologies being transferred, and the user's prior knowledge about technologies being transferred. This framework allows the implementation of the research and provided the researcher with expectations about the data collection and analysis process.

Chapter 4 presented and justified the selection of a qualitative multiple-case study approach as the most suitable design for this study; the chapter presented the data collection, analysis and discussion process. Moreover, the chapter presented the ethical concerns and considerations for the study. Finally, the chapter presented the rigour test executed for this study.

In Chapter 5, background information about the context of this study was presented. The first section presented an overview about Oman, the country within which this study is hosted. This background was followed by detailed information about the two firms that were judgementally selected for this study. Background information included their economic and technological development. This background information established the context for this study and paved the way for the data collection process from the two firms.

Chapter 6 presented the first level analysis of the data collected from the two firms in what was called the within-case analysis. The different experiences and perspectives of the two firms with technology transfer through intermediaries were presented. This analysis enhanced our knowledge about each firm as a standalone case before conducting the cross-case analysis. This analysis also highlighted the emergent patterns from each case.

The analysis of Chapter 6 paved the way for the theoretical and cross-case analysis that was presented in Chapter 7. The cross-case analysis enabled the search for common patterns in the two cases, and consequently drew a more holistic picture of the technological learning through intermediaries. This chapter also included a discussion of the main findings about that lead to identify the main influential factors, and led to the development of a revised conceptual framework. These factors are proximity of intermediaries with respect to sources or recipients (geographical and cognitive), specialization of intermediaries (industrial or

technological domain or both), characteristics of technologies being transferred (tacitness, complexity and novelty), users' absorptive capacity and technology strategy. The empirical findings highlighted how these factors influenced the functions of intermediaries, and in turn influenced technological learning.

Chapter 8 concluded this study and presented an overview of the entire research. In particular, this chapter highlighted the contributions of this study to knowledge and practice, the implications of the findings, and the limitations of this research. The implication allows policy makers and practitioners to benefit from the results obtained through a scientific based approach to improve the practices of the technology transfer through intermediaries. The limitations are opportunities for future scholars to do further research on this phenomenon from different angles.

## ***8.2 RESEARCH CONTRIBUTIONS***

Any scientific research is expected to contribute to the generation of original knowledge. This study integrated two bodies of literature that are often studied separately; the literature on technological learning via the technology transfer and literature on technology intermediaries. Consequently, the study contributed theoretically and practically on both literatures. However, before presenting the contributions, it is worth mentioning the context of the study upon which these contributions are obtained.

This study was implemented on two major national firms operating in the oil and gas industry located in the Sultanate of Oman, which is a technologically lagging country and geographically isolated from most technological sources – producers. The two firms possess weak internal technology production capacity (i.e. R&D department). Moreover, technologies in oil and gas industry are characterised by a high level of complexity and tacitness (Chima et al., 2002; Woiceshyn and Daellenbach, 2005). For instance, a field monitoring technological system is composed from multiple technologies that are merged into a single system. The multiple technologies track different elements of the system and advice on different actions for the users. Moreover, as technologies is moving towards more smartness in which technologies are trained to respond to certain changes in the field, the level of interface between the actual technologies and the operating

computers has also increased. This level of interface has increased the complexity of various technologies utilised in the oil and gas industry. This level of complexity and tacitness in technologies requires capable suppliers to simplify them to a level understood by recipients (Minbaeva and Michailova, 2004; Simonin, 2004). In addition, learning and innovation in oil and gas industry is driven by specialised producers (Pavitt, 1984); who often invest in R&D activities to produce new technologies or systems. Such suppliers contribute to recipient's learning through demonstration and simplifications (Capannelli, 2001). Where such suppliers are not involved with users during the transfer process, user's learning remains not adequately understood.

Importantly, along the course of this study users refer to two main types of intermediaries – consultants and agents. Users identify consultants based on their prior related knowledge about the industry while agents are often understood as manufacturing representatives. This study contributed to the literature on technological learning via technology transfer and literature of technology intermediaries based on the above context and understanding of users.

### **8.2.1 THEORETICAL CONTRIBUTIONS**

This study has yielded several theoretical contributions to the literatures of technological learning via technology transfer and technology intermediaries. It contributed to the literature on technological learning via technology transfer for firms in developing countries (e.g. Bell and Pavitt, 1993; Cyhn, 2002; Figueiredo, 2003; Kim and Nelson, 2000; Kim, 1999, 1980; Ngoc Ca, 1999; Sazali and Rose, 2011; Viotti, 2003). While that literature examined firm's technological learning during the direct supplier-user relationship, this study examined technological learning when suppliers are technology intermediaries who emerged between suppliers and users. Moreover, this study modified the framework of this theory by adding two stages of demand articulation and market scanning, beside the three stages of acquisition, assimilation and innovation.

This study combined the literatures of technological learning and technology intermediaries to examine the influence of intermediaries on technological learning during the technology transfer. Most previous studies on technology



intermediaries (e.g. Kilelu et al., 2011; Leonard-Barton, 1984; Shohet and Prevezer, 1996; Szogs et al., 2011; Tran et al., 2011) implicitly assume intermediaries are service providers in terms of transferring the physical technologies from producers to users. Accordingly, these studies identified the different functions that intermediaries perform for users to transfer technologies from producers. However, this study views intermediary as direct suppliers whose role, according to Cyhn (2002) and others, goes beyond the transfer of physical technologies to include the role of technological tutoring to enhance user's learning. This combination of the two literatures has changed the roles assumed for intermediaries and consequently has modified the conventional understanding of technological learning for firms in developing countries that are isolated from original sources of technologies thus rely on intermediaries to access external technologies and also possess weak internal technological capability.

Whereas the current technological learning via technology transfer process suggests technological learning goes through three main stages of acquisition, assimilation and innovation (e.g. Dahlman *et al.*, 1987; Figueiredo, 2003; Kim, 1987; Lall, 1992; Viotti, 2002), this study argued for the significance of two additional stages prior to acquisition stage, especially when technologies are transferred through intermediaries. The two stages are the demand articulation and market scanning. Consequently they were added to modify the technological learning theory to include a total of five stages. The two stages are often discussed within the literature on technology intermediaries, but they have not received adequate attention in previous technological learning studies, particularly for firms in developing countries (e.g. Bell and Pavitt, 1993; Dahlman et al., 1987; Kim, 1999, 1980; Kumar et al., 1999; Sazali and Rose, 2011; Viotti, 2003, 2002)

This study suggested that the demand articulation and market scanning stages are crucial for firms in developing nations that are isolated from the original sources of technology and lack initial capability. Therefore, technological learning via technology transfer is a process that goes through a sequence of five stages instead of only three as widely proposed by the traditional technological learning theory. Accordingly, the functions of intermediaries and the factors that influence those

functions were identified across these five stages on this study in order to examine user's learning.

The combination of the two literatures led to a further theoretical contribution, which is the development of a conceptual framework of the key factors that have been identified to influence consultants' and agents' functions along the technology transfer process within the Omani oil and gas sector. These factors are the proximity of intermediaries with users (geographical and cognitive), specialization of intermediaries (industrial or technological), characteristics of technologies (tacitness, complexity, newness), recipient firm's absorptive capacity and recipients firm's technology strategy. These factors were initially suggested as influential factors based on prior studies and were confirmed and validated through the experience of the two firms. In addition, the firm's technology strategy emerged as a new factor significantly influencing the functions of intermediaries.

The empirical findings confirmed the initial framework that, according to Eisenhardt (1989), strengthened the basis for believing that those factors were crucial in examining technology transfer and technological learning through intermediaries for firms in developing countries that are isolated from original sources of technologies.

As highlighted in Chapter 2, theoretical and empirical research on the factors that influence technology transfer through intermediaries is limited, as is research on how such factors influence technological learning (Knockaert and Spithoven, 2012). Despite the ample research that has investigated the different functions of intermediaries, those factors still remain an important area of investigation. By identifying and examining those factors, this study offered an improved understanding on technology intermediaries that has the potential to enhance the ability of firms to effectively transfer technologies and develop technological capability through the use of intermediaries.

Importantly, this study is leading in the examination of intermediaries from the theoretical stance of technological learning framework. The adaptation of this framework for examining intermediaries' functions is valuable given the limited amount of research that has adopted this framework to examine intermediaries,

particularly in the context of developing countries. This adoption adds extra dimension to the conventional technological learning theory via technology transfer (e.g. Kim, 1980; Dahlman et al., 1987; Viotti, 2003; 2003). Whereas previous studies on technological learning via technology transfer implicitly assume suppliers are producers, this study assumed suppliers are intermediaries and accordingly examined learning via technology transfer process.

Most previous studies on technology intermediaries do not explicitly mention the theoretical stance of their studies. Moreover, previous research has called for further empirical investigations of technology intermediaries and firm learning (see for example, Knockaert and Spithoven, 2012). Intarakumnerd and Chaoroenporn (2013) similarly noted that little is known about technology intermediaries functions for firms within the developing countries, or how they might influence firm's learning. This study is an early attempt that responds to such calls, and its empirical findings add new insights to the literatures on technological learning and technology intermediaries.

A further theoretical contribution is that, as a result of examining technology intermediaries from the standpoint of technological learning, this study redefined the existing understanding of technology transfer capacity (disseminative capacity) of suppliers when they are intermediaries. Whereas the existing definition of the transfer capacity focuses primarily on the ability of suppliers (producer) to articulate and communicate technologies to a level understood by receipting (e.g. Cyhn, 2002; Minbaeva and Michailova, 2004; Szulanski, 1996); this study redefined it to include the ability of suppliers to absorb technologies from original sources when suppliers are intermediaries.

While previous definitions assume suppliers are producers who are knowledgeable about the technologies being transferred, this study has dropped this assumption for intermediaries until they absorb technologies from original suppliers, before they can effectively disseminate it to recipients. This suggests that technology transfer through intermediaries is a double transfer process. The first process is the transfer of technologies from producer to intermediaries, which requires absorptive capacity of intermediaries, while the second transfer process

involves the transfer of technologies from intermediaries to end recipients, which requires a disseminative capacity of intermediaries. Therefore a lack of either of these capacities (absorptive or disseminative) can lead to a failure in the transfer process.

Consequently, due to the lack of either capacities or both, this study has identified that not all intermediaries are effective at generating firms' learning. For instance, since consultants often possess an adequate level of both capacities, they are often credible and reliable sources for firms' learning and are often involved along the four stages of the transfer process. Consultants can also act as interpreters and translators of external technologies to local context, in addition to their local functions, in order to ensure the suitability of the technology to local recipients and the match with specific local demands.

In contrast, due to a lack of one or both capacities, technology agents are often less effective for firms' learning, and the functions they perform are often limited to linkage and logistical support. In general, the study found that consultants' functions are of a more intellectual nature compared to agents who tend to undertake more physical functions.

Moreover, previous research has highlighted the expansion and growth of technology intermediaries in the technology transfer market and the lack of quality control measures in the market. For instance, within the context of the Omani oil and gas sector, Khan (2010) highlighted "there has been a boom of companies providing services in the oil sector" (p. 286). However, this boom has not been accompanied by adequate regulations to ensure the quality of the emerging service providers (intermediaries). To an extent, Bessant and Rush (1995, p. 103) stated, "one unwanted side effect of such rapid expansion (of intermediaries) was the lack of quality control and there were instances reported of poor and unprofessional conduct amongst small sections of the emerging consultancy sector". This study extended this argument further and identified that the recipients' technology strategy can act as a market regulator and quality control measure to ensure that intermediaries possess certain levels of capability and competency prior to their involvement in a technology transfer project. This

regulatory function of the firms' technology strategy has the potential to enhance the overall effectiveness of the transfer and learning process.

Furthermore, this study contributed to literature on technology intermediaries by clarifying the lack of adequate clarity surrounding some previous contradictory results about the influences of intermediaries on the transfer and learning process, as was discussed in the literature review (e.g. Bessant and Rush, 1995; Howells, 2006; Leonard-Barton, 1984; Shohet and Prevezer, 1996). While previous studies identified the positive or negative influences of intermediaries on the transferability of technologies, they did not offer adequate explanations to what caused these contradictory influences.

This research found the positive and negative influences of intermediaries are largely determined by the five factors identified and empirically examined in this study, that can influence either collectively or individually on the functions of intermediaries. As a result of the influences of these factors on the performance of intermediaries, not all consultants are effective for users' learning, and similarly not all agents are ineffective. For instance, this study suggested that a lack of sufficient information about technologies diffused to users by some intermediaries is largely due to the influence of proximity and specialization of intermediaries.

This study also contributes to the literature of technological learning by highlighting a new function for the absorptive capacity of the recipients of technologies (Kim, 1999; Viotti, 2003). Whereas previous studies have examined the influence of absorptive capacity on firms' internal learning (e.g. Cohen and Levinthal, 1990; Kim, 1999; Mowery and Oxley, 1995; Viotti, 2002), this study identified a new function, which is the quality assurance function for intermediaries. Firms with high level of absorptive capacity were found to be more actively involved with intermediaries along the transfer process and determined the depth and breadth of different services offered by intermediaries. Such users often lead and drive the transfer process. In contrast, intermediaries were found to drive and lead the transfer process with less capable users thus screened the level of information diffused to users about technologies.

Given the significant roles played by general and specialized industrial consultants for local firms' learning, and given that they contribute to complement the lack of internal knowledge production with local firms, it might be argued that local firms do not need to invest heavily in R&D as much as has been previously thought. The empirical findings suggest that local firms can upgrade technologically by embedding in a network of capable and knowledgeable consultants, through which the firms can access valuable knowledge for local learning.

This suggests our understanding of the absorptive capacity of firms in the oil and gas sector may need to be modified to take into account how absorptive capacity can emerge within networks of competent suppliers as well as in R&D. This finding goes alongside the findings of Dantas and Bell (2009) on how firms in the oil and gas sector can learn and upgrade technologically by embedding in a network of competent users and suppliers of technologies.

### **8.2.2 PRACTICAL CONTRIBUTIONS**

The empirical evidences generated by this research based on the experiences of the two leading firms in the Omani oil and gas industry suggest that, despite many firms in developing countries transferring technologies through intermediaries, they may still lack a clear understanding of the best practices for effective technology transfer that is likely to contribute towards firm's learning. For instance, in the contexts of this study at least, there was a lack of knowledge among the local users about what key characteristics of intermediaries enable them to transfer certain types of technologies such as complex or new technologies. Users in the case study context also lacked an understanding of the primary functions that intermediaries should perform during the transfer process to ensure its effectiveness, and what factors influence how well they can undertake those functions.

This study provides several useful insights for managers and practitioners alike when transferring technologies through intermediaries, not least the match between the characteristics of technologies being transferred in terms of technical complexity and newness, and the characteristics of intermediaries in terms of proximity and specialization.

This research advocates that, in order to reap the maximum benefits of technology transfer, recipient firms should target potential intermediaries for technology transfer based on their observed characteristics (such as specialization and proximity). For instance, an intermediary who lacks proximity with users (cognitive or geographical) and therefore may lack the knowledge on needs of the user may be found to be less effective at transferring complex technologies. Consequently, intermediaries of this kind should probably not be selected to support transfer process involving tacit or complex technologies.

Likewise, intermediaries that are too close to users (geographically or cognitively) are locked-in the experiences of the users and become part of users network thus are less effective in the transfer of new technologies, and again should probably not be selected for such technology transfer projects. The empirical evidences of this research found the right match between the characteristics of technologies and that of intermediaries was found to be crucial to ensure effective technology transfer process and learning in the case study contexts. Moreover, this match fitted and identified within a theoretically rich framework of this study, suggesting it can be more generalized.

The findings also highlighted that an intermediary that is involved with users during demand articulation stage is more effective for adapting those technologies in the internal system compared to an intermediary who was not involved in that stage. Since the demands are mainly articulated through either problem definition or opportunities identification, both approaches require intermediaries to be knowledgeable about the internal technological system of users, which in turn enhances their capability to adapt external technologies to the internal system.

The empirical findings suggest that firms that have accumulated prior related knowledge and experience (absorptive capacity) about the technologies being transferred often achieve superior technology transfer outcomes in terms of learning. A strong prior knowledge base allows firms to become more active participants during the transfer process rather than accepting blindly and passively technologies that are selected and diffused by intermediaries. This is important as passive participants run the risk that intermediaries will control the

entire transfer process and screen the level of information. Absorptive capacity (prior knowledge) not only influences firms' internal learning but also influences the functions of intermediaries (suppliers) especially when it comes at information diffusion.

For instance, within the context of this study it was found that, intermediaries tend to diffuse a greater depth of information about technologies to knowledgeable users compared to less knowledgeable users. Knowledgeable users also tend to be more active participants during the transfer and learning process and are more capable at both defining the specific functions that intermediaries perform during the transfer process and ensuring their quality. Active users are often better able to counteract the agency power of some intermediaries or the monopoly they exercise on the information they possess about technologies, compared to passive users.

Lastly, the results suggest that firms' technology strategy should consider emphasizing technological learning as a strategic objective during the transfer process. Where this is the case, firms could establish a set of technical criteria for intermediaries who are considered capable of assisting the achievement of the strategic objectives. Defining technical criteria for intermediaries allows the technology strategy to act as a market regulator for intermediaries eligible to become technology suppliers for local firms. Where such criteria are not in place, many service providers evolve in the market without ensuring their technical capability, which eventually could negatively influence local firms' learning. Consequently, before embarking on the technology transfer through intermediaries, recipient firms should look for real evidence that intermediaries possess the capabilities they claim and perform effective transfers that include physical technologies and associated technological knowledge.

### ***8.3 RESEARCH                  IMPLICATIONS                  AND                  POLICY RECOMMENDATIONS***

This study found that five factors have an influence on the way intermediaries perform different functions during the technology transfer process. These factors



are the proximity of intermediaries to users, technical specialisation of intermediaries, characteristics of technology being transferred, capability of user firms, and finally the technology strategy of user firms. These factors can lead to what might be called a division of labour among different intermediaries during the transfer process.

The influences of those factors would have serious implications on government and firms' policies that aim to initiate and strengthen the functions, roles and contributions of intermediaries within a national learning system. Government and firm policy should encourage joint efforts and collaboration among different intermediaries, therefore helping to enhance local learning. For instance, in settings like the case study where agents and consultants are distinct, policy might ensure collaboration between agents that have a wider access to a network of suppliers and consultants that possess valuable industry and context specific knowledge.

Second, in settings like the case study, national and firm policy should emphasize learning as a strategic objective during the technology transfer process and, accordingly, ensure resources are developed and allocated. For instance, a lack of strategic recognition of the role and importance of technological learning during the transfer process means there may be a lack of technical criteria that regulate the functions of intermediaries in the local technology transfer market. Both the government and firms should consider this issue seriously in order to advance national and firm learning through the inward technology transfer through intermediaries. Likewise, firms should be concerned to continuously develop their internal capacity to become familiar with the range of technologies utilized in the industry, so the employees become active participants along the transfer process and are capable of counteracting the agency power of intermediaries.

Third, given that private intermediaries dominate the local technology transfer market within the Omani oil and gas sector and that not all of them were found to be effective in supporting learning within local firms or are not involved with users after the actual transfer, the government may wish to consider whether there is a market failure in operation, particularly if intermediaries do not invest in their

ability to develop and support local learning. One proposed strategy for the government to counterbalance the market failure is the development of public intermediaries such as the research councils and research centres. These intermediaries might create a market competition with private intermediaries in the winning of technology transfer projects based on superior competency. This policy has the potential to lead to technological upgrading within both; firms and intermediaries, which eventually will benefit the firms' learning.

Different organizational set-ups of intermediaries such as public, private or on-line could be designed to achieve different objectives by undertaking different functions. Where there is a dominance of a single type, such as the private sector, as in this case, national learning might not be of interest to private intermediaries. It has long been recognized in prior studies that firms, as private entities, tend to invest less in the development of the national learning system such as in R&D activities, leading to "market failures" of this kind (Ngoc Ca, 1999). As a result, when firms are left to themselves they will tend to under-invest in innovation and knowledge production activities with a public good nature.

Fourth, specialized intermediaries (consultants) were found to be more effective for local firms' learning and innovation as they were often valuable and credible sources of knowledge. However, due to a lack of proper infrastructure such as R&D facilities that these intermediaries require, they are typically located in advanced countries that are far from local firms. Government policy may wish to offer incentives for specialized intermediaries to participate in the local technology transfer process more extensively. This would be particularly useful in the case study setting as learning in the oil and gas sectors is largely led by specialized suppliers (Pavitt, 1984). As a result, localizing specialized intermediaries might be one of the government policies used to enhance local firms' learning. This can be implemented by investing on the development of advanced local R&D facilities, in addition to other incentives that could attract such intermediaries.

#### ***8.4 LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH***

Great efforts have been made for this study in terms of research design and fieldwork, in addition to the data collection and analysis. However, due to

limitations in some resources (financial, human, time), the study suffers from several limitations that may provide opportunities for future research.

Firstly, the empirical evidence is mainly based on the perspectives of the recipients of technologies, which is only one side of the technology transfer process. A two-side perspective (that addressed both source and recipient) would provide a more balanced understanding and hence a fuller examination and comparison between the two sides of the relationship.

Second, the findings of this study were also based on the experiences of the two major firms within the Omani oil and gas sector. Although these firms were selected judgmentally and purposely as content-rich firms for the phenomenon being researched, the findings need to be interpreted with care and have the potential to be sector specific. Consequently, future studies may wish to incorporate firms from more sectors, of different sizes, and from different countries. That is important because of the contextual nature of intermediaries' functions (Clarke and Ramirez, 2013). However, the results obtained by this study can be still analytically generalized for similar contexts or for intermediaries operating in sectors other than oil and gas.

This study offered an increased overall understanding of what possible factors might influence the functions of intermediaries along the transfer process and how that might influence the local firms' learning. Hence the study presented a great source for future research that could examine the functions of intermediaries in similar or different contexts, with a great care to the context specifics of each case. Nonetheless, the study involved several contextual elements such as the sector specific, the characteristics of the firms in terms of age, size and capability, besides other socio-economic elements that might influence the transfer process.

Third, this study examined the functions of two main types of intermediary, consultants and agents, and the factors influencing those functions. Future research can include other types of intermediary. Importantly, the intermediaries examined in this study were all private sector entities. It is not yet clear whether the results obtained would be equally applicable for public sector intermediaries. Future research may wish to incorporate other types of intermediaries, such as

public or online intermediaries, and compare the findings across different organizational set-ups.

### ***8.5 SUMMARY***

For high-tech industries in Oman, such as oil and gas, most technologies are produced in developed countries like Japan, Korea, the USA and Europe. Being isolated from producers, in addition to weak internal R&D capability to produce technologies, has driven the emergence and growth in technology intermediaries to support the technology transfer process. Factors such as proximity, specialization, technologies, and capability of users, in addition to firms' technology strategy, are all crucial for the effectiveness of technology transfer through intermediaries. These factors influence the different functions that different intermediaries can perform during the transfer process from producers to users. A good understanding of these factors can increase the firm's ability to effectively transfer technology and enhance technological learning.

Moreover, these factors generate a division of labour among different intermediaries along the transfer process. Government and firms' policy should concern issues such as the 'division of labour', and joint activities or collaboration between different types of intermediaries. It does not mean that the different types of intermediaries must have a mutually exclusive relationship but that they should engage each other either directly or indirectly along the transfer process. This collaboration enhances the effectiveness of technology transfer and firms' learning.

For instance, consultants should play an active role in performing activities that are necessary for the technological upgrading of firms in the sector. These activities include information processing, creating new functions, connecting local firms, and providing important training in critical skills and knowledge, that cannot be accessed by local firms, providing testing facilities and initiating R&D to generate value addition along the chain of the industry. On the other hand, agents should support these activities. Where intermediaries do not perform such activities (i.e. market failure), government policy should intervene to rectify the failure and ensure the effectiveness of the transfer and learning process.

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## APPENDIX 1

### Interview questions

The following section illustrates the main questions (opening questions) that were employed to interview participants. However, while semi-structured interviews were employed, these questions were followed by various probing questions that vary from one respondent to another according the data collection process in order to confirm an answer of previous interviewee or get a clarification about it. The focus of the interviews is to explore what factors influence the functions of intermediaries along the five stages of the transfer process and how those factors influence user's learning.

Based on the conceptual framework developed for this study, four factors are thought to influence the functions of intermediaries. These are the proximity of intermediaries to users, specialisation of intermediaries, characteristics of technologies being transferred, and the capability of users. The following questions assess how these factors influence the users learning.

- **Technology transfer process**

- ✓ How do you define a technology? What does it constitute?
- ✓ Could you describe the process of transferring technologies from external sources? What are the main stages/tasks of the transfer process? Could you provide example of a real transfer process?
- ✓ Who are the parties involved along the different stages of the process?
- ✓ How do you define the process of technological capability development along the technology transfer – technological learning?

- **Technological learning**

- ✓ How do you develop technological capability about the transferred technologies? Can you describe the process of technological learning along the transfer process? What are the factors that might influence your learning along the transfer process?

- **Intermediaries**

- ✓ Can you define technology intermediaries?

- ✓ From your experience, why they are involved in the transfer process in the company?
- ✓ What are the different types of intermediaries that are involved along the transfer process?
- ✓ What differentiate/characterise each type? What are the main tasks that each type performs?
- ✓ From your experience, do intermediaries perform the same tasks along the transfer process? Or each type perform certain tasks? Why? what are the factors that might influence the functions/tasks of intermediaries along the transfer process? Could you provide example please?

▪ **Proximity (geographical and cognitive)**

1. Spatial

- ✓ Do you think the location of intermediaries influence what functions they perform along the various stages of the transfer process (involvement in the transfer process)? How? Could you provide example?
- ✓ How did you find your learning experience along the technology transfer stages from intermediaries located in Oman vs. those who are not? Is your experience the same for all types of intermediaries? How? Could you provide example?

2. Share of organisational language and culture:

3. Do you think the organisational language or culture influence what functions an intermediary perform along the various stages of the transfer process (involvement in the transfer process)?

4. Did you notice that intermediaries who has worked in the local oil and gas industry are more involved along the transfer process in comparison to intermediaries who has not? How? Could you provide example?

- ✓ How did you find your learning experience along the technology transfer stages from intermediaries who worked previously with you (in the company or similar local company) vs. those who have not?

- ✓ Do you think previous experience of intermediaries in the firm influence how they diffuse technologies or the functions an intermediary perform along the process? How?

5. Share of Knowledge base:

- ✓ Do you think the functions that are performed by an intermediary with oil and gas knowledge and experience vary along the transfer process from an intermediary with no or weak industrial knowledge or experience? Why? Could you provide example?

- ✓ Did you notice learning from an intermediary with oil and gas experience varies from an intermediary with no or weak industry experience? How?

**6. Spatial and cognitive proximity:**

- ✓ How did you find your learning from an intermediary who possess industrial knowledge and experience and located in Oman vs. an intermediary who possess the same knowledge and experience but not located in Oman? Did you find/notice that the combination of the two elements of the proximity influence the functions that an intermediary might perform along the transfer process? Could you provide example?

▪ **Specialisation:**

- ✓ Did you notice that the prior knowledge and experience of an intermediary influence the functions they perform along the transfer process? How and why?
- ✓ How did you find prior work and experience of intermediaries influence your learning along the technology transfer stages? Is it the same for all intermediaries? How? Could you provide example?
- ✓ Did you find the period of time an intermediary worked in the industry influences your learning along the technology transfer stages? How?
- ✓ How did you find the industry-specific knowledge influences the capability of intermediaries to diffuse technologies along the transfer stages so that you can absorb and internalise the technologies being transferred? Could you provide example?
- ✓ Did you find the prior work experience of an intermediary influences the types of technologies an intermediary can transfer? How? Could you provide example?
- ✓ How did you find learning from an intermediary who doesn't possess an industry specific experience? Is it the same for all types of intermediaries? Is it the same for an intermediary located in Oman vs. that who located outside? How? Could you provide example?
- ✓ How did you find learning from an intermediary with work experience from other industries? Is it the same for an intermediary located in Oman vs. that who located outside? How? Could you provide example?



- ✓ How did you find learning from an intermediary who specialises in the oil and gas industry but not located in Oman?
- ✓ Did you find the past experience of intermediaries influences their diffusion capability of different technologies? How does that influences your learning along the transfer process? Could you provide example?
- **Characteristics of technologies (simple, complex, newness):**
  - ✓ Do you think the characteristics of technologies influences the transfer capability of intermediaries? How?
  - ✓ Do you think the transfer capability of an intermediary for different characteristics of technologies is influenced by their proximity (spatial or cognitive) with respect to users? How? Why?
  - ✓ How did you find the combination of characteristics of technologies and proximity of an intermediary influences the transfer capability of intermediaries? How does that combination influences your learning from intermediaries along the transfer process? Is that the same for all intermediaries?
  - ✓ How did you find the combination of nature of technologies and prior work experience of an intermediary influences the transfer capability of intermediary? How does that combination influences your learning from intermediaries along the transfer process? Is that the same for all intermediary?
- **Internal capability of users (absorptive capacity: prior knowledge about technologies being transferred)**
  - ✓ How did you find your prior knowledge about the technologies being transferred influences the transfer process? Why? How does that influence your learning along the transfer process?
  - ✓ Did you notice that the prior knowledge influences the attitude of intermediaries, such as their willingness, along the transfer process? How? Could you provide example
  - ✓ Does your prior knowledge about technologies being transferred influence all types of intermediaries and with all types of technologies? How?
- **Company technology transfer strategy**
  - ✓ Do you think the company has developed technological capability to improve the characteristics of or produce an alternative technology of any transferred technologies? How? Why?

- ✓ Did you find the company support your various activities of learning such as attending technical workshops or conferences, scholarships...etc? How? Why?
- ✓ Does the company allow to experiment the functionalities of existing technologies? Why?
- ✓ How are your learning efforts perceived by the company? Do you get motivated or financially supported by the company for your learning achievements? Why?